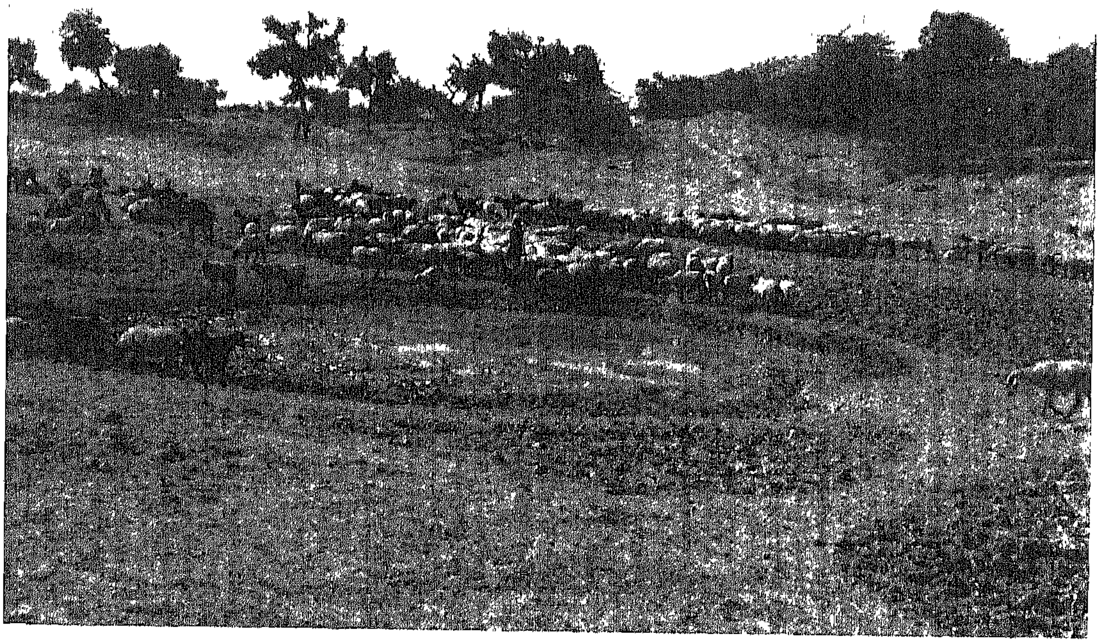
SHORT COURSE

on

"FEEDING OF LIVESTOCK DURING DROUGHT AND SCARCITY"

(November 1-10, 2006)



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INDIAN COUNCIL OF AGRICULTURAL RESEARCH

NEW DELHI

at

DIVISION OF ANIMAL SCIENCES & FORAGE PRODUCTION

CENTRAL ARID ZONE RESEARCH INSTITUTE

JODHPUR – 342 003

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"FEEDING OF LIVESTOCK DURING DROUGHT AND SCARCITY"

(1st November to 10th November, 2006)

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FOREWORD

Indian subcontinent is more prone to droughts- their frequency, intensity and impact vary greatly with the geographic area. Droughts cause misery both to human and livestock due to the widespread crop failures leading to acute shortages of food and fodder and affecting human and livestock health, nutrition and production. Scarcity of drinking water particularly in arid region further aggravate the situation.

Indian arid zone essentially represents an animal based agricultural economy. The region is most prone to the droughts and in the past century the frequency of agricultural drought has been 43 to 68 years in one place or the other, sometimes wide spread in nature. Droughts persists in some areas for 3 to 6 years having a multiplying effect and exert tremendous stress on natural resources leading to scarcity of water, food and fodder.

There has been considerable work done by ICAR research Institutes, State Agricultural Universities, Deptt. of Animal Husbandry and Non Government organizations to combat drought effect on animal productivity and health. However, the drought management takes a form of crises management which needs to be a long term planning as short term strategy leads to uneconomic cost involved towards provision of relief measures like feed, fodders and water and its transportation to the destination.

The various technologies developed at the Central Arid Zone Research Institute, Jodhpur like feed and fodder banks, supplementary and complete feed blocks, use of newer feed resources in formulating economic rations, Physical and chemical treatments of feeds and fodders need planning for its implementation at farmer's level . There is an urgent need to impart knowledge on advances made in feed security measures in terms of quality and quantity for its implementation during drought period.

The task of providing training and have interactions on "Feeding Livestock during Drought and Scarcity" has been assigned to CAZRI, Jodhpur by the Indian Council of Agricultural Research, New Delhi. During the training, the scientists of this Institute, resource persons and line deptt. personnel will deliberate on technical advancements to ensure feed and fodder security during drought situations so that optimum animal production is maintained. I am glad that the training manual to be distributed to the participants has been brought. I am sure; this publication will be very useful to the scientists, administrators, development agencies and field workers engaged in livestock management programmes in arid and semi arid regions. I congratulate the Course Director and his team and especially all Contributors to bring out this useful manual and wish a great success in this short course.

31/8/06

(PRATAP NARAIN)
Director

Preface

In India due to its wider geographical diversity, erratic behavior of monsoon and uneven distribution of rainfall the agriculture always remains to be a gamble and facing of drought and floods simultaneously remain an annual reality. In certain parts of the country, drought like situation is an often perpetuate phenomenon and therefore termed as "normal situation" to that region especially in parts of Gujarat and Rajasthan.

Livestock play a special role in the drought prone areas where it contributes significantly to the GDP in these areas. Livestock provides a more sustained income to the farmers. The nature has also endowed these areas with some of the best breeds of cattle, sheep, goats and other species of livestock. During an acute 90 percent rainfall deficient year grain production may nose dive to less than 10 percent but production from livestock may be assured at more than 50 percent of the normal year. The drought prone area is also endowed with nutritious perennial grasses. But the failure of rain affects directly the growth of grasses as well as water resource to the livestock. And it results in loss of animal production and high mortality. Therefore ensuring feed /fodder security for animals remains foremost priority during the droughts. The endemic nature of drought in certain parts of the country, notwithstanding, drought management, takes the form of crises management, which perhaps reflects the absence or lack of long term planning to tackle natural calamities. A long-term strategy is required to tackle the drought and drought proofing of drought prone areas of the country. This requires diversification of agriculture on the one hand, while feed resource planning on the other.

Various advances made in the drought proof feed and fodder security technologies need proper implementation to save the valuable animal germplasm and also to ensure proper level of profitable production level. This will in turn help the small and marginal farmers in the country to gain their livelihood.

In recognition of highly expertised manpower and useful technologies developed, the Central Arid Zone Research Institute, Jodhpur has been identified to impart training on "Feeding of Livestock during Drought and Scarcity" to researchers, teachers and extension workers working in different fields of livestock production. The participants during the said course will be exposed to technological advancements made in the field of feeding management, feed and fodder processing, planning and integrating various feed resources and technologies for ensuring balanced feeding for livestock, management of grazing resources/ pastures, development of Silvipastoral system, identification newer feed sources and management of water resources as a drought proofing measure for livestock.

This manual is a write up of technical deliberations and it is expected to help devise a strategy to combat deleterious effects of drought on animal wealth and its production which remains an important source of livelihood for about 70 per cent farmers of our country.

(N.V. Patil)
Course Director

Contents

FEED AND MANAGEMENT IN ARID REGION

Pratap Narain
Central Arid Zone Research Institute, Jodhpur

Indian arid zone covers 31.8 lakh km^2 nearly to 10.16% of total geographical area. The hot region of nearly 62% lies in the state of Rajasthan covering 12 western districts of Barmer, Bikaner, Jaisalmer, Jodhpur Churu, Nagaur, Jalore Jhunjhnu, Sikar, Pali Hanumangarh and Ganganagar.

The region suffer from low and erratic annual precipitation (100-420 mm), high evapotranspiration (1500-2000mm) and poor physical and fertility condition of soil making crop farming a big gamble. Animal husbandry plays an important role in livehood security and economic sustenance of people. The arid region has about 28.57 million livestock population which during last century has increased by 61%. The man: livestock ratio is much higher in arid area and presently per 100 human population there area 124 livestock numbers in the area which may go to 200-300 is extreme districts of this zone indicating economic dependency of farmers on livestock husbandry (Narain and Rajora 2004).

In spite of harsh climate and feed scarcity, arid region is gifted with best breeds of cattle; Tharparkar, Rathi, Kankrej and Nagauri. Sheep: Chokla,Marwari, Magra, Jaisalmeri, Patanwadi, Nali and Pugal, Goats:Marwari, Kutchi and Camels: Bikaneri, Jaisalmeri and Kutchi.

Tharparkar cattle breed is native of Thar desert and reared primarily for milk production. Rathi, a milch cattle breed found widely among nomads who maintain these animals on ranges. The Kankrej and Nagaur are excellent drought breeds. The wool produced by arid sheep is of coarse and carpet type and annual production is about 1.5 to 2.0 kg whereas the goats often termed on poor man's cow has a distinct social, economic , managerial and biological advantages over other livestock in the region (Singh 2004).

The drought in the arid region is a common occurrence with frequency as high as 48 to 63 in past century and sometimes persistent of 3-6 years, which affect agricultural and fodder production. This coupled with degraded pastures due to overgrazing cause feed deficit for large population of animals.

In India there is shortage of 40% dry and 25% green fodder (FAO 1998). In Rajasthan the fodder deficit in western Rajasthan is estimated to be as high as 60% of the demand and might range form 55% in western Rajasthan districts of Bikaner, Jaislamer and Barmer to 69% in the Central districts of Jodhpur, Nagaur and Churu and 72% in the eastern districts of Pali and Sikar. During drought years the overall deficit might go as high as 76% of the demand, and may range from 76% in fodder situation is better due to excellent pasture of L. sindicus western districts to 81% in the central districts and 82% in the eastern ones (Venkateswarlu et *al.* 1992). It is unavailable that inspite harsh climate situation in higher arid areas. The acute shortage in the central and eastern districts is on account of extensive cropping, fragmentation of land holdings, intensive cultivation and shrinking of pastures and grazing lands. The gap between the demand and supply will continue to widen if appropriate strategies are not initiated to enhance biomass and forage production substantially.

Nearly 1/3rd area of arid zone of Rajasthan are wastelands, of which 50% are grazing lands and 45% are sandy wastes (Balak Ram, et *al.* 2005). The production from the available grazing lands is hardly 300-400 kg/ha/biomass. In the recent past, there has been a general awakening at various levels among land and stock owners regarding the need for an application of advanced technology to improve the deteriorated and depleted range pastures, in order to obtain a sustained level of production through management practices based on accepted principles of range management which include 1) Adoption climax key species in the range and 2) the concept of relative potentialities of individual species in a range grassland community from the point of view of animal grazing capacity and utilization.

The situation further warrants adoption of other feed management strategies for ensuring feed and forage availability from agriculture ,forest and other areas during the droughts without further delay for supporting the livestock component of agriculture which remains base for livelihood of peasants of this region. Various approaches for ensuring feed and fodder security are discussed in this chapter.

1. Management of Grasslands

The grazing based animal agriculture is the predominant occupation and major source of livelihood of the people in arid regions.The rangelands occupy on an average 45 percent land and in extreme arid tracts like Jaisalmer 95% of the area is used as rangelands or grazing lands(Shankar and Kumar,1987). Lands of arid Rajasthan are in depleted condition due to their overexploitation, abuse, encroachment, inadequate protection and absence of any grazing policy. These lands have potential to produce 4 to 5 times forages or even more by adopting following appropriate management practices.

Need of proper land use policy

Lands falling under Class V to Class VIII land capability classes are unfit for crop cultivation and those under class IV are subject to wind and water erosion. These lands should be utilised for pasture/ grassland development, and not forced under cultivation. Such policy will augment forage production and control land degradation.Areas receiving <500 mm average rainfall are cultivated mostly with pearl millet, cluster bean, mothbean and mungbean. In sandy soils with less than 200mm rainfall *Lasiurus sindicus* has been found most adaptable and productive over all other grasses and which need be promoted.

Considering the fact that the relative palatability of a range species determines its intensity of use by the grazing livestock, observations recorded by Dhabadgao and Murwaha (1962) for five of the most important species of arid Western Rajasthan; and palatability rating done by comparing them with *Dichanthium annulatum*, grass considering its palatability 100 per cent indicate the importance of arid grass species for arid rangelands. (Table 1and 2 below).

Table 1 - Relative palatability of six arid zone range grasses (for cattle)

	Pasture stage	Pre-flowering	Flowering stage	Ripe stage	Deap ripe stage
Dichanthium annulatum	100.0	100.0	100.0	100.0	100.0
Cenchrus ciliaris	51.9	169.7	52.8	125.0	266.7
Cenchrus setigerus	43.9	55.6	32.4	97.1	216.7
Lasiurus sindicus	43.2	31.5	37.9	109.7	125.0
Panicum antidotale	19.0	30.8	10.7	38.5	16.7
Panicum turgidum	49.7	14.0	31.2	59.4	33.3

Table 2 - Average nutritional values of some range grasses

Range Plant Species	Percentage of dry matter yield			Total available digestible protein (kilo/hectare)
	Crude protein	Phosphorus	Digestible protein	
Cenchrus ciliaris	*12.82*	*0.517*	*8.60*	*522.15*
Cenchrus setigerus	*8.77*	*0.602*	*4.89*	*168.87*
Panicum antidotale	*12.24*	*0.489*	*8.07*	*667.92*
Dichanthium	*5.05*	*0.482*	*1.48*	*19.05*

annulatum				
Lasiurus sindicus	*9.05*	*0.557*	*5.15*	*287.31*

Protection of grasslands

Fencing of an area is essential to alleviate heavy livestock pressure. Barbed wire fencing is by far the most effective and economical in long run. But the initial cost of fencing is very high hence the farmers may construct ditch and core wall fencing through participatory approach. Border can be planted by species like *Acacia senegal,* A. *tortortly,* A. *nilotica var. cuprisiformis, Calligonum polygonoides* and *Capparis decidua.* It has been proved that by mere protection, a lot of benefit in terms of vegetation availability can be obtained. After 2 years of protection, the forage yield is reported to increase by 148, 92 and 116% in 'poor', 'fair' and 'good' classes of rangelands, respectively in the tropical arid region, having sandy-loam soils (Paroda, et *al.* 1980). Similarly Cleaning of thorny bushes like *Lycium barbarum, Balanites aegyptica, Acacia leucophloea and Mimosa hamata,* should be done mechanically to improve grassland productivity.

Reseeding of grassland

Reseeding with high yielding perennial forage species suiting to arid tracts need be done for ensuring optimum grass production from the rangelands. It involves soil working, seeding of grasses and after for desired cover.

Recommended pasture grasses: Dichanthium annulatum on heavy soils with annual rainfall above 380 mm, *Cenchrus ciliaris* and *Cenchrus setigerus* on well-drained soils under medium to low rainfall, *Lasiurus sindicus* on sandy soils with low precipitation, *Panicum antidotale* on well-textured soils with annual rainfall of 250 mm and *Sehima nervosum* for hilly terrain are recommended grass species. The high yielding varieties of theses pasture grasses viz., CAZRI 75 of C. *ciliaris* and CAZRI 76 of C. *setigerus* are good varieties developed by CAZRI which can be utilized for reseeding.

An un-notified variety CAZRI 358 is doing well in almost all the habitats of arid zone. The variety has wider adaptability and can tolerate grazing pressure.

Soil Management involves land ploughing and unwanted vegetation be grubbed by the end of June. Sowing of mixture of seeds @ 5-7 kg ha^{-1} is recommended to take care of rainfall aberrations and speed of germination. The grass seed should be mixed with 4-5 volumes of moist field soil and drilled uniformly 2-3 cm deep in lines 75 cm apart after the first effective rains and covered with light soil. Depending upon rainfall, dressing of 20-40 kg N/ha is recommended to reap higher forage production from reseeded grasslands.

Such reseeded grasslands need at least two weeding in first year of establishment. The reseeded grasslands should not be opened for grazing in the first year of establishment. In the second year and onward grazing should be so regulated that proper seed formation and shedding of seeds take place to guarantee satisfactory regeneration.

In order to improve productivity water conservation measures such as contour furrows, contour bunds and staggered contour trenches are extremely valuable .Reseeding of *Cenchrus* species in furrows revealed 130% increased production over control (Singh, 1992). Inter-row water harvesting system in which 30 cm wide ditch alternated with 70 cm wide raised bed was planted with two rows of pasture legume and grass on the edge of the ditch. This system of planting increased fodder yield of legumes and grasses by 124 and 66%, respectively over conventional flat bed system of planting (Singh, 1992).

Productivity potential of arid grasses:

Well-established pastures become ready for cutting/grazing even after a fortnight of effective monsoon. The dry matter production of pasture grasses on demonstration plot was 30-35 q/ha for C. *ciliaris,* 20-25 q/ha for C. *setigerus,* 35-40 q/ha for *L. sindicus* and P. *antidotale.*

Cost: Benefit of reseeding of pasturelands

Cost of reseeding varies from Rs 3500-4000 ha^{-1} with a return of Rs 1000 to 2000 ha^{-1} in first year but higher returns in subsequent years with little inputs make the reseeding practice cost effective. Over a period span of five years benefit: cost ratio becomes as high as 3.13:1 (Table 3;Gajja, 2000).

Table 3. Benefit: cost ratio of pastures in arid zone of Rajasthan

Establishment year	Cost (Rs/ha)	Returns (Rs/ha)	B:C ratio
1 year	5050.	1250	0.25:1
2 year	2000	2600	1.3:1
3 yea r	2000	5250	2.63:1
4 year	2000	6250	3.13:1
5 year	2000	6250	3.13:1

2. Pasture/grassland utilization: Considering low yield of pasture in arid region and high labour cost, harvesting is not a viable proposition unless mechanized harvesting and bailing is restored to, where sandy terrain imposes some difficulties. In case of reseeded, established and fertilized pastures, if forage yield are high, it is better to harvest 1/4th of the area at 50% flowering and preserve it as hay for feeding to milking stock, suckling, sick animals and working bullocks during adverse conditions. Preservation of surplus fodder can be brought about through hay and silage making, by treatment of roughages and bailing to blocks/rolls to facilitate transportation.

Controlled grazing: Most of the naturally growing grasses are very poor in productivity; the problem is further aggravated by grazing for excess to carrying capacity. Improvement of degraded grasslands need protection; controlled grazing and introduction of high yielding perennial pasture grasses and eradication of unpalatable perennial shrubs/grasses. Condition of grassland is very crucial for controlled grazing, which depends upon carrying capacity (Table 2). Grazing saves the cost of harvesting of poor uneconomical grassland and offers ground exercise to livestock. Livestock while grazing work up the soils, manures grazing lands, break the top crust of the soil, thereby encouraging better percolation of water and range production. Deferred rotational grazing is best practice advised for low rainfall regions but covered with high yielding nutritious *L.sindicus* grass spp. to increase number of grazing days, maintenance of proper vegetation through self seeding, fertility levels of soil and to minimize erosion.

Table 4.Carrying capacity of various classes of pasture

Condition class of pasture	No. of ACU (300 kg body wt) per 100 ha	Productivity (q/ha)
Excellent	25-30	15
Good	20	10
Fair	17	7.5
Poor	13	5
Very Poor	6 and less	2

3. Top feed-cum-shade trees and shrubs on grasslands

Traditionally a few feed fodder cum shade trees are maintained on pastures to supplement nutritious fodder during lean period as well as to provide shade in hostile weather. These trees are heavily lopped, exploited and are in depleted poor state. *Prosopis cineraria,* which is extensively lopped in winter, can withstand recurrent lopping without causing any detriment at effect a its growth or subsequent leaf yield. A moderate sized mature tree of the species yields about 15 kg of leaf forage locally known as *'Loong'*. Z. *numularia* locally known as *'bordi'* is also heavily lopped in winter for its leaf fodder known as *'Pala'*. Investigation at Pali and Jodhpur has shown that the species growing at medium density of 14% is optimum in natural grazing lands for maximum fodder production, which may yield about 125 kg of *'pala'* per ha.

Some suitable top feed species on rangelands with systematic lopping should be integrated for good pasture management. Trees can also be planted along the boundaries, inspection path and approach roads to serve dual role of windbreaks and source of fodder. A good pasture may have 30 to 35 such trees per hectare. The important top-feed-cum-shade trees for rangelands are *Acacia nilotica, Prosopis cineraria, Salvadora oleoides, Acacia senegal, Albizia lebbeck, Anogeissus rotundifolia, Anogeissus pendula, Azadirachta indica, Grewia tenax*, G. *spinosa, Techomella undulata and Hardwickia binata*. Shrubs like Z. *nummularia, Calligonum polygonoides, Ha/oxylon salicornicum, Capparis decidua* and *Acacia jacquemontii* are also relished by goats, camels and livestock.

4. Silvipasture Systems for Fodder Production: Silvipastoral system is best suited for areas receiving <200 mm rainfall, or for degraded rocky-gravelly areas. Tree species highly compatible with grasses are: A. *senegal*, A. *tortilis*, A. *lebbek*, *T. undulata*, *Colophospermum mopane*, *Dychrostachys nutans*, *Hardwckia binata*, Z. *nummularia* and Z. *rotundifolia*. Among the pasture legumes *Clitoria ternatea* and *Lablab purpureus* showed good compatibility with L. *sindicus* and C. *ciliaris*. The carrying capacity of a pure pasture was found to be 3.9 sheep per ha after 9 years of establishment, while that from a silvi-pastoral system was 8.5 sheep after 7 years. Under grazing study, Z. *nummularia* with grass strips in 1:2 ratio led to higher economic returns due to higher weight gain of the animals and higher wool production. Silvipastoral studies involving plantation of A. *tortilis Azadirachta indica*, A. *lebbek*, *Holoptelia integrifolia*, and C. *ciliaris*, C. *setigerus*, *D. annulatum*, and P. *antidota/e* revealed non-significant differences in grass yield at Pali, which was 2.8 t/ha for *D. annulatum*, 2.5 t/ha for C. *ciliaris* and 2.2 tjha for P. *antidota/e* (Muthana and Shankarnarayan 1978).

Growth and top feed production of Z. *nummularia* and Z. *rotundifolia* on established pasture of C. *ciliaris* at Samdari showed that after five years of establishment, growth of the jujube species was more than two times and *'pala'* production was more than six times in control (no pasture) as compared to established pasture due to competition of grasses. However, the total forage production varied from 135 to 1269 kg/ha^{-1} and pasture yields were non significant with or without jujube. Planting of jujube in pasture is recommended at 6 m x 6 m spacing (Sharma and Vashishtha 1985).

In an improved silvipasture, H. *binata* was taken as tree component at 3 m x 3m with C. *ciliaris*. Results of nine years study (Table 5) revealed that average carrying capacity of the system was 4.1 sheep/ha/year against 3.7 for sole pasture and 1.6 for sale tree plantation (Narain and Tewari, 2005). Silvipastoral systems having a three-tier canopy, i.e. grass + legume (first tier), shrubs (second tier) and fodder-cum-fuel trees (third tier) must be given high priority for improving the feed availability in this region.

Table 5.Production potential of *Hardwickia binata* + *Cenchrus ciliaris* based improved Silvipasture

Year after planting	Grass yield (q/ha)	Leaf fodder yield (q/ha)	Total fodder yield (q.ha)	Carrying capacity (sheep/ha/yr)
1	8.2	-	8.2	1.9
2	12.3	-	12.3	2.9
3	16.4	-	16.4	3.9
4	20.5	-	20.5	4.9
5	16.4	-	16.4	3.9
6	16.4	-	16.4	3.9
7	12.4	23.1	35.5	8.5
8	8.4	6.6	15.0	3.6
9	8.4	6.6	15.0	3.6
Average	13.3	4.0	17.3	4.1

6. Forage production from sandy wastelands: There is vast potential of augmenting fodder production from 6.36 million ha wasteland particularly sandy wastes and land with and without shrubs, which constitutes about 1/3rd of waste lands. Silvipastoral system with multipurpose tree species like P. *cineraria* and Z. *nummularia,* and grasses for increasing the forage production from degraded and waste lands should be a loud recommendation.

In arid zone of Rajasthan, sandy wastelands occupy 45% of the area. If stabilized and managed properly, these lands offer a huge potential productive site for afforestation and grassland development. Rehabilitation of sand dunes involves (i) protection against biotic influences, (ii) treatment of shifting sand dunes by fixing barriers (mulching-micro wind breaks) from the crests down to the heel of the dune, (iii) afforestation by direct sowing and or planting of suitable tree species, and planting of seedlings or root slips of drought hardy perennial tussocky grasses. In such areas, grazing should not be allowed till the dunes are stabilized and grasses may be harvested manually to provide longevity to grass species.

7. Orans and Gochars as source of pasture grasses.

Orans and gochars occupying about 62,000 ha, so called the Sacred forests, were traditional systems of grazing prevalent in arid western Rajasthan. These lands were attached to deities and were excellent source of biodiversity conservation. With passage of time there is a large scale encroachment on these grazing ground and these are on the path of degradation due to change in human values. By extra efforts, potential of such lands is required to be harnessed to supplement fodder during the stress.

8. Forage Production from Irrigated Areas

Forage production from a portion of cultivated area is practiced, where rearing of improved livestock like buffalo, high yielding cattle is common. Crop sequences for production of high yields of nutritious green fodder in irrigated areas are: Sorghum-berseem-pearl millet, maize+cowpea-berseeem-pearl millet and NB hybrid intercropped with berseem. Staggered planting of cropping sequences in rotational fashion by sub-dividing forage field in 2-3 plots, conservation of excess fodder as silage or hay during lush green period will solve many problems of drought affected region.

Recommended Fodder crops and their varieties

Sorghum	:	PC 6, PC 9, PC 23, HC 171, HC 260, SL 44, MP Chari, HC 136, Raj Chari 1, Raj Chari 2, Meethi Sudan, X 988, MFSH 3.
Pearlmillet	:	Giant Bajra, UUJ-IV-M, Rajko,
Maize	:	Africal Tall, Vijay Composite, Moti Composite.
Cowpea	:	EC 4216, Bundel Lobia 1, Bundel Lobia 2, UPC 5287
Berseem	:	Mescavi, Wardan, BL 22
Guar	:	FS 277, HFG 119, HFG 156, Bundel Guar 1, Bundel Guar 2.
Hybrid napier	:	Pusa Giant, IGFRI 10.
Setaria	:	Nandi, Kazungula, Narok.
Guinea grass	:	Hamil, PGG 1, PGG 9.
Dinanath grass	:	PS 3, Bundel Dinanath 1, Bundel Dinanath 2.

9. Judicious use of feed resources -Creation of feed/fodder banks.

In large part of the country the dry and green fodder, straws and stovers are offered to animals without chaffing, resulting wastage of large portion of these resources. The practice of chaffing of fodder, straws and stovers should be popularized, which will enable more availability of energy for animal production. The technologies like urea treatment and complete feed by incorporating non-conventional feed resources, minerals, and complete feed blocks will also help in availability of more nutrients from existing quantity of feed resources.

Fodder banks: Storage of fodder from good to bad years was a traditional drought coping mechanism in arid region. One of the major issues that need greater attention is fodder bank creation in arid region, creation of fodder banks at Panchayat Samit levels may be enforced for fodder security in famine years. The fodder bank concept should include bailing/densification, storage and transport of fodder to cater the need of deficient areas. The fodder bank could be the ultimate solution and contingent plan to meet the demand of lean period shortage particularly during drought and floods. These banks could be used for following feeds and fodder. Feed bank for ingredients unfit for human consumption, grasses from periphery of forest area, wastelands and farm lands stored as briquettes and high density stacks, crop residues in densified form, coarse cereals , legumes, haulms left after grain removal can also be stored.

10. Policy Intervention

Legislation

There is an imperative need for feed and fodder development policy at national level. Establishment for Feed and Fodder Development Board can effectively work as a core instrument to achieve the policy goals for this sector.

To develop a grazing policy for the region, a policy for use of permanent pastures, as well as policy for animal migration is called for.

Strict enforcement of the policy decisions through dialogue and attractive schemes may help ease the pressure on degraded grazing lands.

Education

Forage production and research should be considered as a national agenda. Chairs should be created in universities/SAUs. for teaching graduate and postgraduate students.

A sound syllabus be prepared, covering all major aspects of forage production and enforced at university level.

Conclusion

A wide gap in demand and availability of fodder and feed in arid western Rajasthan is reflected in low productivity of animal wealth, so important for sustainable livelihood particularly in drought years. There are opportunities for augmenting productivity of forages in arid regions. Traditional systems of "Orans" need to be rejuvenated and maintained to reduce pressure on grazing lands. Improved grassland technologies envisaging protection of area, reseeding with high perennial grasses, soil and water conservation, utilisation of pasture, management of excess forage and scientific methods of grazing can enhance productivity of these lands manifold. The non-conventional systems viz., silvipasture and horti-pasture, and forage production systems can be widely adopted on wastelands constituting 1/3rd of arid region in western Rajasthan.

The management techniques to ensure feed and fodder security are improvement in the production potential of fodder trees, bushes, range grasses and legumes for increased biomass availability.

Conservation of grasses germ plasm, breeding for biotic and abiotic stresses and introduction of short duration forage crops in the cropping system.

Appropriate strategies for efficient utilisation of the existing feed resources and conservation of surplus fodder of normal years. To establish feed and fodder banks, storage and transport of fodder from excess to scarcity areas.

Policy intervention for promotion of fodder production, protection of grazing lands, minimise fragmentation of land holdings and use of tractors on grasslands.

Maximize forage production from non-conventional systems and problematic areas Training and education of farmers to popularize the grassland/ fodder production technologies.

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MAJOR NUTRITIONAL IMPLICATIONS AND STRATEGIES TO OVERCOME ILL EFFECTS OF DROUGHT IN LIVESTOCK

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Drought can be defined as adverse moisture index or adverse water balance, which may be due to generally a prolonged dry spell or insufficient rainfall. But factors such as excessive evapotranspiration, high temperature, and low moisture conservation capacity of soils also aggravate the drought situations. If dry weather persists and water supply-related problems increase, the dry period can be called a 'drought'.

In India with 70% per cent of its 1000 million population dependent on agriculture and allied activities though have large water resources and have an annual rainfall ranging from 10,000 mm at Cherapunji, 8500 mm in western ghats to 200-300mm in parts of western Rajasthan and Gujarat, still find relevance in the old adage that Indian agriculture is a gamble dependent on the monsoon. The country faces typical situation of drought and floods simultaneously. Further the quantum of rainfall received may not be as important as the pattern of rainfall, otherwise Cherapunji recording highest rainfall in the country would not face water scarcity during lean season. Whereas in the parts of Rajasthan, Gujarat the drought like situation often perpetuate which may be termed as normal situation in the region. Widespread crop failures leading to acute shortages of food and fodder adversely affecting human and livestock, health and nutrition; scarcity of drinking water accentuated by deteriorating ground water quality and declining water tables leading to migration are the major manifestations of droughts and these need be taken care of as a management policy as the droughts have become a recurrent feature.

Drought occurrence and its causes in India

In past century, the country has experienced twenty one large-scale droughts with greater frequencies during the periods 1891-20, 1965-90 and 1997-2000 Large parts of the country perennially reel under recurring drought. Over 68% of India is vulnerable to drought. The 'chronically drought-prone areas' – around 33% – receive less than 750 mm of rainfall, while 35%, classified as 'drought-prone' receive rainfall of 750-1,125 mm. The drought-prone areas of the country are confined to peninsular and western India – primarily arid, semi-arid and sub-humid regions.

The 1987 drought was one of the worst droughts of the century, with an overall rainfall deficiency of 19%. It affected 59-60% of the crop area and a population of 285 million.
The monsoon of 2000 was the 13th consecutive normal monsoon considering country as a whole, but on a regional basis, this was the third consecutive drought year in areas covered by the states of Rajasthan, Gujarat and Andhra Pradesh.

Reasons for the droughts in India

The El Nino phase of the Southern Oscillations (ENSO) having a direct impact on weak or enhanced summer monsoon, responsible for 70-90% of annual rainfall, is responsible for drought in India (WMO 1994).
Reckless over-exploitation of surface and groundwater caused sharp decline in groundwater levels, leading to a fall in supply, saline water encroachment and the drying of springs and shallow aquifers. In some regions the decline in water levels has been to the extent of 1-2 metres/year. The declining water levels could lead to a 25% drop in harvests in the near future (Seckler, 1998).
The rapid depletion of forest cover is also seen as one of the reasons for water stress and drought. While erratic monsoons and drought are intertwined, a host of other reasons, mostly manmade, – poor irrigation systems,

pressure from the increasing industrial use of water aggravate drought or create drought-like situations in the country.

Drought classification

There are a number of classifications and considering Physical aspects the droughts may be clubbed into three or four major groups:

Meteorological drought is deficiency in rainfall compared to the average mean annual rainfall in an area. Meteorological drought occurs when the seasonal rainfall received over an area is less than 75% of its long-term average value. If the rainfall deficit is between 26-50%, the drought is classified as 'moderate', and 'severe' if the deficit exceeds 50%.
Agricultural drought occurs when there is insufficient soil moisture to meet the needs of a particular crop at a particular point in time. Deficit rainfall over cropped areas during their growth cycle can destroy crops or lead to poor crop yields. It is typically witnessed after a meteorological drought, but before a hydrological drought.

Hydrological drought is a deficiency in surface and sub-surface water supply. It is measured as stream flows and also as lake, reservoir and groundwater levels.

Impact of droughts

The agricultural sector is usually the first to be affected because of its heavy dependence on stored soil water. Soil water can deplete rapidly during extended dry periods. If precipitation deficiencies persist, then people dependent on other sources of water begin to feel the effects of the shortage. Those who rely on groundwater, for instance, are usually the last to be affected.
When the situation returns to normal, and meteorological drought conditions have abated, the 'recovery cycle' follows the same sequence. Soil water reserves are replenished first, followed by stream flows, reservoirs/lakes and groundwater.

Management of drought: role of government functionaries

The endemic nature of drought in certain parts of the country, notwithstanding, drought management takes the form of crises management, which indicates perhaps the absence or lack of long term planning required to tackle natural calamities. Nevertheless the management strategy for drought relief consists of assessment by revenue authorities of the state governments to measure the gravity of drought situation and an area is declared drought affected when there is damage to more than 50 per cent of standing crop. If the situation is beyond the means of the state govt. to handle, central assistance is sought. After visit of an inter-ministerial team to the affected states and submitting report to the Ministry of Agriculture, the recommendations are put up National Calamity Relief Committee (NCRC) for a final decision.

Funds from calamity relief fund, contributed by central and state governments in the ratio of 3:1, are provided for an action plan drawn by affected States to deal with affected livestock, in inter alia includes sourcing and transportation of water, fodder and opening of fodder depots, cattle camps, release of feed grade grains by the FCI and above all coordination of the various agencies engaged in relief work.

Drought and agriculture production

The immediate effect of drought is decline in food production. The general pattern of rainfall distribution indicate that south west monsoon is important precipitation source in India
An overwhelming majority of cropped area in India – around 68% – falls within the medium and low rainfall ranges. Large areas are therefore affected if the southwest monsoon plays truant.

Table 1. Cropped area falling under various ranges of rainfall

percentage distribution)

Range of rainfall	Classification	%
Less than750 mm	Low rainfall	33
750 mm to less than 1,125 Mm	Medium rainfall	35
1,125 mm to 2,000 mm	High rainfall	24
Above 2,000 mm	Very high rainfall	8

Source: Ministry of Agriculture-2002 GOI

Most parts of peninsular, central and northwest India – regions most prone to periodic drought – receive less than 1,000 mm of rainfall. The drought of 1965-67 and 1979-80 affected relatively high-rainfall regions, while the drought of 1972, 1987 and 2002 affected low-rainfall regions, mostly semi-arid and sub-humid regions.

There is a high degree of correlation between food grains production and the monsoon rain pattern-production is higher in years when rainfall is in excess of normal and a dip in years of deficit rainfall.

The drought of 1987 was one of the worst in the century. The overall deficiency in rainfall was 19% as compared to 26% in 1918 and 25% in 1972 being worst years. In the two worst affected states of Rajasthan and Gujarat, the rainfall was less than 50% from normal. In these states, the drought of 1987 was the third or fourth in succession resulting in distress to an unprecedented level. Nearly 54000 villages faced acute drinking water problem .The total area and production in Kharif and rabi food grains reduced by 6.7% and 3 %, respectively and it was compensated by increase in area and production under rabi oilseeds by 19.9 and 24%, respectively.

No other drought in the past led to such a drop in food production as the 2002 drought. Food grain production was reduced by about 19%.(Table-2)

Table 2. Kharif output in drought years

Deficient rainfall years	Monsoon rainfall (% departure from normal)	Kharif foodgrain production (% decline)
1972-73	24	6.9
1974-75	12	12.9
1979-80	19	19.0
1982-83	14	11.9
1986-87	13	5.9
1987-88	19	7.0
2002-03	19	19.1

The percentage fall of kharif and rabi crop acreage, was about 50%.Production of rice, pulses, commercial crops, oilseeds, Cotton and sugarcane declined by about 7 to 19%. This made it the largest rabi drought in any drought year. The drought of 2002 highlighted the vulnerability of irrigated areas to drought.

Simulation models using soil, plant and water (SPAW) developed to assess impact of drought years on pearl millet yield in Jodhpur was found to be close to observed data and therefore, useful for yield estimation (Rao and Saxton 1995 b).Similar approaches are needed to be worked out for all agro climatic regions to plan alternate cropping policy in case of failure of principal crops during drought.

Range plant response to drought

In the rangelands drought not only reduces forage production but it also lowers forage quality.As the soil moisture becomes less available, the leaf and shoot growth is slowed. Tillering in the grasses is reduced. With the persistence of drought conditions – leaves wilt, fold, become discolored and may eventually die. Even under mild water deficit conditions, there is a reduction in cell wall formation, cell division and protein synthesis. Plants adjust to low soil moisture by shutting down and going dormant. This results in reduction in total amount of above and below ground plant biomass production. During drought periods plants utilize carbohydrates of previous growing season that available in the roots, or crown of the plant. This drain of carbohydrates results in loss of root vigor and fewer basal buds develop for next year's growth. Thus drought not only reduces the forage yield in the drought year but also in subsequent years, even if growing season moisture is adequate.

The plants of arid and semi arid regions have evolved to grow and reproduce when soil moisture is sufficient. If soil moisture is not adequate the plant growth will be reduced despite the peak growing season. However, if there is leaf material present for photosynthesis to occur, energy will be provided to the plants roots and to its developing basal buds for next season's growth.

Grazing management during drought

Good grazing management results in much leaf material, which is essential for taking advantage of any moisture that does occur to produce energy for its roots and basal buds. The less energy the plant is able to provide to its roots the more vulnerable it becomes to the drought and to grazing.

A drought may require that livestock numbers be reduced according to forage supply. Rotational grazing system in drought is to be preferred over continuous grazing as periodic rest helps plants maintain vigor. Concentrating more animals in a single herd is recommended over having several smaller herds as by having more animals in a pasture, the entire pasture will be grazed more uniformly and more use of less preferred plants will be made.

Drought effect on animals

The major effect due to reduced availability of feed resources is wide scale mortality in animals. In Rajasthan change in livestock composition since 1951 indicate that sheep and camels followed by cows were most vulnerable animals and they perished in large numbers ranging from 10 to 32%.The situation of various states during drought of 2002-03 is given in Table-3.

Table 3. Impact of drought of 2002 on bovine nos. and fodder production

State	No. Bovines affected (Lakhs)	Fodder deficit (lakh Mts)
Gujarat	54.84	2
Andhra Pradesh	153	61.61
Chattisgarh	17.22	4.2
Karnataka	100	60.09
Madhya Pradesh	192	7.8
Maharashtra	189	241.77
Orissa	117	Surplus
Rajasthan	226	149.31
Tamil Nadu	86	Surplus

Source-Ministry of agriculture, GOI,2002.

Primary survey in 2002 indicated a loss of cows in large numbers i.e. 25 to 50%. The goats and sheep were relatively less affected compared to large animals. These animals depend on common property resources i.e. grazing lands, wastelands, forests etc. and movement to better endowed areas saves them in severe drought, they move out of state and in worst situation they are sold for slaughter. These animals are reared for ready cash and to meet milk demands of families. However, the health of these animals is affected due to loss of vegetation of their choice. When rain occurs there is a change in type of vegetation for grazing and few animals can not adjust and die (10% of the total number, Rathore 2005).

Nutritional consequences of drought in the ruminants

Drought has important nutritional consequences in terms of scarcity of both, water and feed on a wider scale and it is necessary to ensure its supply for survivability of livestock. In addition to the amount, the quality of water and feed is also deteriorated in drought periods. There has been little fundamental research on the nutritional consequences of drought for ruminants and other farm species, but it is possible to construct from first principles a satisfactory explanation of metabolic mechanisms invoked for survival in a drought and the reasons why, for example the breeds -Marwari and west African goat, Marwari Sheep and Tharparkar Cattle and even donkeys appear to thrive in conditions that are intolerable for the exotic or crossbred animals.

Overgrazing in the drought areas is a major factor of quality deterioration of pasture and even in the area which has not been overgrazed the plant material available on the range is extremely fibrous and low in CP which not only limits feed intake but also causes malnutrition, reduces production and even influences survivability. The impact of drought on livestock is manifested in four ways--- i) Mortality ii) Loss in productivity iii)Health of animal and (iv) Loss in fertility.

Body weight loss as a measure of under-nutrition

The first and foremost effect of limiting the nutrients to the livestock due to droughts or feed scarcity situations is loss of body condition. If the animal has good fat reserves it will use these as a source of energy during weight loss. Animal deaths in drought are mainly due to exhaustion of body fat reserves. The tissues of animals dying from starvation for example, contain less than one percent crude fat (Champion, 1971). Critical body weight is the body weight below which mortality rate rises rapidly. Definite threshold values are difficult to give and depend on duration and type of underfeeding, as well as on the loss of production that is considered acceptable.

The survival or critical body weight varies with species, strain, breed and age of the animal. It has been reported that cattle will die if weight loss is > 20% of body weight, while sheep and camels can tolerate weight loss up to 30% of the body weight (Leng and Preston, 1987). Cronje (1990) gives critical bodyweight losses of 30 - 40% in cattle and sheep. Obviously, the weight loss that can be tolerated depends on the original weight and condition of the animals, as well as on the physiological status of the animals: i.e. young stock tolerates less weight loss compared to mature animals (Cronje, 1990). An adult animal in good condition can also lose more weight than the same animal in poor condition. Knowledge of critical weight losses for different species is required to optimize feed resource allocation during emergency, but these are not commonly available in India. It would also be useful to use or" develop condition scoring techniques to estimate how much weight individual animals are able to lose.

The effects of temporary weight loss can be recovered by compensatory gain (O'Donovan, 1984) especially in growing animals. For milk production, the effects of periodic under nutrition on general health and fertility reproduction are however more likely to be of a long term nature. Lactation curves are unlikely to recover and calving rates and conceptions may be lowered (Allden, 1970; Robinson, 1990).

Considerations for water during a drought.

The water availability during a drought is essential as water helps to regulate the body temperature, for transport of nutrients, etc. The water requirement is related to factors like heat load, production traits and DMI.

The water requirement of an animal is in the range of 2.5 to 4.5 l/kg DMI. Murphy et *al.* (1983) gave the following equation for lactating cows in early lactation in Western conditions mainly:

Water intake (kg/day) = 15.99 + [(1.58 ± 0.271) * DMI] + [(0.9 ±0.157) * kg milk/day] + [(0.05 ±0.023) * sodium intake in g/day] + [(1.2 ±0.106) * minimum daily temperature in °C]

Water requirement

This depends upon environmental temperature and physiological needs of animals.

A cattle above 27 deg centigrade atmospheric temperature requires 5.5 litres of water per day. A pregnant cattle requires 9 litres of water per day. A milch cow needs 0.87 litres of water per litre of milk produced in addition to its requirement of 5.5.

In case of sheep water requirement is 3 kg per day, 5 kg per day is needed for pregnant sheep & milk.
For other animals water requirement can be assessed on the basis of above principles.
The ratio of Water Intake: DMI will also rise if feed intake is restricted. Therefore, it may be better to express water requirement as a percentage of body weight.

Extending watering frequencies to 2-3 days have proven to be practical during drought periods for large ruminants when water is scarce. This has the advantage of reducing overall feed and water consumption with possible improved nutritional benefits in terms of increased feed digestibility (Leng, 1986) which may be due to increased retention time of digesta in rumen. Body reserves were unaffected due to extending water up to 3 days as compared to daily offered (Leng, 1986).

The effects of restricted water intake include reduced urine output and reduced feed intake. If the water deprivation is severe, dehydration will occur, combined with protein catabolism and finally a failure of the renal function.

Water requirements of cattle may double during hot weather. If cattle do not have sufficient water, they may refuse to eat, experience lower production, and become sick.

During hot, dry weather one concern about cattle drinking stagnant pond water is that animals can die if the water contains certain species of blue-green algae as these are favorable conditions for its growth. But not all blue green algae are poisonous, and the blue green algae that can generate poisonous toxins do not always do so. It congregates on or near the water surface.

Convulsions, bloody diarrhea, and sudden death characterize intoxication with blue-green algae. Clinical signs also include nervous derangement, staggering, tremors, and severe abdominal pain. If concentrations of blue green algae are suspected, dead animals such as mice, muskrats, birds, snakes, or fish may be present near water source.

Dietary energy and protein considerations of livestock during drought

During drought conditions, dietary energy in the available grazing feeds may be low because dietary fiber content is high and because degradable N content cannot sustain sufficient microbial growth in the rumen and /or hindgut to ensure optimal fermentation of potentially digestible dry matter. Thus even though the feed available may be plenty the animal has difficulty in consuming enough ME for maintenance within the constraints of gut fill. Still the tropical breeds excel in their adaptive capability to low energy due to lower metabolic heat requirement at maintenance. And the lower BMR of *Bos indicus* confers greater tolerance to both heat and drought (Frisch and Vercoe, 1977).However extended drought periods causing low forage production results in livestock to range further to obtain necessary amounts of DM to meet their nutritional needs. This increased travel results in the expenditure of additional energy that may result in a loss in body condition for mature animals and reduced gains in immature stock. Besides producing less forage, drought stricken plants also contain lower concentrations of crude protein, energy, vitamin A and phosphorus. Thus grazing animals need to consume a greater quality of forage to obtain needed nutrients.

Pastures dormant due to drought conditions are usually deficient in protein. The adaptation of the species like goat, sheep to the drought conditions has a greater ability to concentrate urine than cattle or horses (Schmidt-Nielsen, 1964; McFarlane, 1976).This ability to concentrate urine not only conserves water, it also conserves urea produced by catabolism of body protein in an animal at or below maintenance. This urea can be recycled to the rumen or hind gut and incorporated into microbial protein. Thus an animal best able to concentrate urine is best able to digest low protein, high fiber; dry tropical grasses. The ability of ruminants to recycle the end products of catabolism of body protein through the rumen in order to generate more ME and amino acids in conditions of drought is undoubtedly of far greater evolutionary and practical significance. But the dietary protein supply if continuously remains to be low as in prolonged droughts the it is bound to affect the production and health of the animals.

Effect of nutritional deficiency on reproduction

In conditions when sufficient nutrients, particularly energy are not available to the cows or sheep/goats, a loss in body condition results causing decrease in milk production and reproductive activity may cease. In pregnant cows the end result is light weight calves and open cows. Fertility of the cows decline when their body condition score (BSC) drops to below 4; especially at calving and if these conditions occur during the breeding season, reductions in pregnancy rate can occur. The overall consequences presented in Table-4 shows the reproduction is impacted most by these deficiencies.

Table 4. Influence of inadequate dietary nutrient intake on reproduction in cattle (Corah, 1988).

Nutrient consumption	Reproductive consequence
Inadequate energy intake	Delayed puberty, suppressed estrus and ovulation, suppressed libido and spermatozoa production
Inadequate protein intake	Suppressed estrus, low conception, fetal resorption, premature parturition, weak offspring
Vitamin A deficiency	Impaired spermatogenesis, anesturs, low conception, abortion, weak offspring, retained placentae
Phosphorus deficiency	Anestrus, irregular estrus
Selenium deficiency	Retained placenta
Copper deficiency	Depressed reproduction, impaired immune system, impaired ovarian function
Zinc deficiency	Reduced spermatogenesis

To prevent such undesirable effects, cows either must be provided sufficient nutrients to avoid weight losses and maintain production requirements or they must be relieved totally or partially from these nutritional stressors.

Strategy of meeting feed requirement during drought

Two feeding strategies, one relates with lack of fodder availability and the other with lack of feed quality can be followed to mitigate effects of drought in livestock.

Feeding strategy during limited feed supply

- Feeding strategies during droughts having lack of feed can have one or more of the following objectives:
- to feed animals for **maintenance** at a minimum body weight, i.e. a strategy to ensure survival of animals from the available feed;
- to feed animals to maintain weight above the critical or minimum bodyweight including allowance for weight gain in growing animals. In a long drought this would mean that less animals would survive as the available feed would be used quicker;
- to preferentially feed productive stock, such as pregnant and lactating cows. This is called strategic feeding, it would again mean less feed for other animals.

I) Reallocation of a given amount of feed in the herd

The first major option to overcome a feed shortage is to adjust the animal production to the feed availability. Thole *et al.*,(1993) gave some hypothetical and simplified calculations on the economics of different feeding strategies . The mortality in herd was assumed to be entirely caused totally by starvation from the animals other than productive stock in no strategy intervention case because no pasture was available and no feed was available to dying animals. Three strategies to adjust feeding patterns and reduce mortality rates considered were:

A) Diversion of nutrients from milk producing animals to all other animals of the entire herd. This would **reduce total milk production** from 290 to 60 litres, greatly reducing farmer's income, but **securing the survival** of more animals

B) Diversion of nutrients from growing animals and bullocks to save other livestock;- If the growing animals were fed sufficient nutrients to gain 400 g/day and bullocks and old cows were offered 80% of their requirement, 10 out of the 29 animals at risk can be saved. In this strategy **milk production is not reduced. And 1/3rd mortality can be reduced.**

C) Diversion of nutrients from both milk producing and growing animals to the starving animals:- In this case farmer does not want to lose so many animals and if he/she cannot afford to cut milk production as drastically as in option A, the strategies can be combined. In this some nutrients would be diverted from milking as well as from growing animals, thereby **saving almost all animals** at the cost of 120 kg milk/day
A reduction of milk yield in Strategy A results in a decreased daily income, which may be difficult to accept for farmers who do not have sufficient other sources of income or cash reserves. The feeding of animals below their requirements (strategy B) is risky because more animals may die eventually if the calamity continues for a longer time.

The choice of strategy is obviously affected by the nature of feed shortage, whether it is regular and predictable or irregular and unpredictable. Both situations are common in the wide variety of Indian farming systems. Strategy B also results in underfed cattle that are less valuable after the calamity. The extra value or costs of these animals is, however, difficult to assess partly because of compensatory gain or lower fertility rates, especially of the younger animals. Also, the value of animal survival is much higher for predominantly Hindu society of India than in many other countries of the world. The relative need to possess an animal that can pull the plough at the next rainy season further complicates the valuation of mere survival as a form of animal production.

II) Purchase of feed from surplus location

The second major option to save animals is to purchase feeds from surplus regions. High transport costs are involved particularly in a large country like India where extreme droughts and rains can occur simultaneously. Although the calculation shows that at larger distances, i.e. beyond 200 km. the cheaper transport of concentrates favors the cost of nutrients from grains over dry grass.

But the option of grain feeding however has limited value as it is already scarce under normal circumstances and are not likely to be diverted from human consumption in the calamity that also affects human nutrition. Therefore, feeds available for purchase include agro industrial byproducts such as bagasse, grain milling byproducts and molasses or grasses and straws from the fields.

The cost to save the animals by diverting nutrients from milk production to the animals at risk (Option A) was 230 kg milk per day, but by purchasing the feed the cost is about 27 % of option (A) on concentrate feed and 17% per day on unconventional feeds like bagasse (Thole et al, 1993).Therefore the transport of nutrients (Feeds) happens to be the best option to save the animals in drought. This situation changes considerably if feed is not available nearby and transport costs are incurred.

Grasses from forest areas or crop residues from regions with surpluses are commonly transported to feed animals during droughts. The possibility of transport depends on the nature of the calamity. Transportation of feed is only an option if the drought is regional. It has little or no value if infrastructure is highly damaged (floods) or if the calamity is of a much larger scale (severe droughts that occur throughout most of India). In the case of the 1984/1987 drought in Gujarat, it was observed that transport costs were at times higher than the costs of the feed itself.Here under some attention is given to the options to reduce transport cost for the bulky feeds by densification.

III) Densification of feeds

One way to reduce transport costs is to compress or to densify the bulky feeds. Jadai et *al.* (1990) reported that there was 2.25 - 2.70 times increase in bulk density of straw based complete feed. Densities can be increased from 65 - 75 kg/m3 to 100 - 110 kg/m3 by baling or even 300 - 500 kg/m3 by briquetting (Bruhn et *al.*, 1975), which seems very high however. Considering the costs of baling grass by hand and bullock driven presses (pada press) the quantity of feed which can be transported in each truck is more than doubled after baling. The calculations of show that when transport distance exceeds 50 and 150 km the costs of baling respectively with pada and hand press are recovered by reduced transport costs. Extra benefits like reduced storage costs, less spoilage and consequently increased quality of the feed are likely to occur but it depends on the type of straw and the method of densification.

IV) Other strategies to overcome feed scarcity.

a) Reduction of wastage by chaffing

If straw is insufficient for feeding of all animals, the reduction of wastage by chaffing is an option which saves 15 - 20% of the the straw offered (Shukla et *al.* ,1988) . In Haryana and Punjab states chaffing is common on farms, but it is not widely practised in other areas, probably for nutritional reasons as elaborated by De Wit et *al.* (1993).

b) Urea treatment of straw

The transport of urea or ammonia, and treatment might be cheaper than the purchase and transport of additional concentrate or roughage (Schiere and Nell, 1993). Urea-treated straw saves on concentrate feeding, increases milk yield by 1-2 litres/animals a day, offers better economic returns to the farmers and may help reducing land area required for green fodder production.The process is very simple and involves spraying of urea solution uniformly over the straw and storing it for a specific time period. The process of urea ammoniation of straw is as follows Straw-1000 Kg, Urea,40 kg and Space requirement is 180 x 150 x 150 cm.. In that case the increased intake of treated straw also helps to improve the health and productivity of animals.

c) Complete feeds

Complete feeds imply a system of feeding all ingredients including. roughages, processed and mixed uniformly, to be made available at *libitum* to the animals (Sharma and Singhal, 1986). It can be in mash and pelleted form when this product is fed as sole source of nutrients. Pelleting feeds increases voluritary intake by 3-30% but adds to processing cost by 57-130% depending upon the type, percentage and original cost of roughages in the ration (Reddy, 1986). If baling of fibrous feeds is practiced, it can be useful to produce complete feeds for use during droughts, i. e. to add some concentrate ingredients. Biologically, the use of complete feeds with an appropriate balance of roughage and concentrates may lead to better utilization of locally available crop residues, agricultural-byproducts and waste. Complete diets for livestock could benefit rural farmers during periods of feed shortage if the feed and transport costs can be kept low. Many complete feeds using locally available byproducts like bagasse, mixed with tree leaves and other unconventional byproducts have been developed. However, the composition of the complete feed needs to be adjusted to the production level of the animals.

d) Use of unconventional feed resources

Non conventional feeds are helpful to reduce the deficit of animal feeds as well as to make livestock production more economical and profitable. Some feasibly used unconventional feed sources could be: *Kuvadia (Cassia tora Linn.) seeds,Vilayati babul Prosopis juliflora Linn.) pods,Babul (Acacia nilotica (L) Del.) pods, seeds and babul seeds chuni,Mahuva(Madhuca indica J.F. Gmel.) seed cake,Mahuva flowers,Mango seed kernel (Mangifera indica Linn.),Sal seed(Shorea robusta Geartn F.) cake,Pilludi {Salvadora oleoides Dane(Var.*

persica Linn.)} cake(deoiled),Subabul (Leucaena leucocephala) seeds,Sea weeds(Sargassum spp.),Molasses,Rubber seed cke(Ficus elastica Linn),Raintree pods(Pithecolobium saman),Tomato (Lycoperiscon esculentum Mill.) waste,Isabgul gola and Isabgul lali(Plantago ovata Forsk.), Tapioca starch waste Manihot esculenta Crahtz.),Tamarind seed powder(Tamarindus indica Linn.),Neem cake(Azadirachta indica A. Tues.),Karanj cake(Pongamia glabra),Niger seed cake(Guizotia abyssinia Cass.),Ambadi cake(Hibiscus canabinus Linn.),Kusum cake(Schleichera oleosa Willd.), Warai bran(Panicum miliaceum),Palm (Borassus flabellifer Linn.) male flower,Damaged Apple Waste (Malus sylvestris),Jowar gluten and jowar cake(Sorgum vulgare Pers.),Banana root bulbs(Misa paradisiaca Linn.

Other unconventioal feeds such as Samadi seeds, Shevari seeds, Pilludi fruits, Cher fruits, Hydrol, Malt waste, Orange waste etc.

e) **Nutrient supplementation strategy during drought.**

Pastures and native range that are dormant due to drought conditions may be low in energy, vitamin A, phosphorus, and protein. Meeting the need for these nutrients is important if herd productivity is to be maintained.

If stocking rate is not reduced as per forage availability, supplemental feeding of the deprived nutrients is necessary to maintain herd productivity and alleviate grazing pressure.

Several options are available for supplying energy to cattle on drought stressed pasture. Hay, grain, and crop processing byproducts can all be used to supply energy to grazing cattle. Low-quality forages can also be ammoniated to increase digestibility and protein content.

As a general rule, up to 0.2 percent of body weight of supplemental grain per head per day will not result in large decreases in forage intake and digestion

Provide dry cows with approximately 250 g of supplemental crude protein and lactating cows with 300-400 g of supplemental crude protein per day. This can be fed as approximately 400-550 g of soybean meal for dry cows and 800 to 1000 g of soybean meal for lactating cows. Feed 400-500 g per day of a high protein supplement to dry cows and possibly as much as 700-1000 g to lactating cows to maintain forage intake and efficient use of the forage.

Protein supplementation may be necessary for optimum breeding rates during drought conditions. Protein supplements (cottonseed meal, soybean meal), commercial protein rich concentrate mixtures would be appropriate. Alfalfa hay, sunflower meal, safflower meal, as well as other protein meals may also be used as protein supplements.

For some grains, processing may be necessary for optimum use by cattle. Corn and oats can be fed whole but may be used better if coarsely rolled before feeding. Barley and wheat, however, should be coarsely rolled. Avoid fine grinding and rolling, which results in excess fines and dust. These can result in increased incidence of acidosis. In addition, extremely dusty supplements are unpalatable. However, the producer must weigh the additional costs of processing vs. the value of the grain.

Grain processing co-products such as wheat midds, soybean hulls, and corn gluten feed that contain highly digestible fiber provide energy while alleviating much of the negative impact that grain supplementation has on fiber digestibility. In addition, these byproducts provide protein that may also be limiting in drought stressed forages.

General recommendations about supplementation with minerals and vitamins.

Similar salt and mineral mixture during drought as during normal conditions may be provided. During drought, however, phosphorus supplementation is even more critical. A complete mineral supplement containing 12 percent calcium, 12 percent phosphorus, 5 percent magnesium, 0.4 percent zinc (4,000 ppm), and 0.2 percent copper (2,000 ppm) has worked well in many areas.

Lack of vitamin A may become a problem during the fall and winter for cows that grazed drought-affected pastures during the summer. Vitamin A is lacking in forages growing under drought conditions and hay produced from drought-affected forages. Cows should receive vitamin A and D booster shots approximately 30 days before calving if they have not been previously supplemented with vitamins.When using byproduct feedstuffs, make sure that the mineral program is balanced. These feeds are typically high in phosphorus and potentially high in sulfur, which may lead to some mineral imbalances.

f) Supplementary feed blocks/mixtures

In case deficiency of multiple nutrients like energy, protein,mineral and vitamins is predicted, the multinutrient bricks /blocks of molasses,urea,mineral and vitamins are preferred for large animals as a lick and multinutrient mixtures can be fed to small ruminants to offset the effects of deficient nutrients.

Conclusion:-

Recurrent droughts prevailing in one or the other parts of the country creating quantitative and qualitative deficiency of livestock feeds demand a policy to mitigate the nutritional deficiency effects in livestock which may include—

1. Develop the feed resource base through establishment of feed /fodder banks based on early warning about drought from meteorological Department.
2. Proper pasture grazing management methods to protect the biomass and ensure future production from the grasslands once the moisture and climate condition favors.
3. Formulate nutrient supplementation policy to avoid loss of production and health.
4. Conserve, utilize and enrich the feed resources from agricultural byproducts, forest grasses, tree leaves, bushes etc. as a drought proof measure.

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LIVESTOCK MANAGEMENT DURING DROUGHT

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With an area of 3.2 lac km^2, the hot arid zone constitutes about 12% of the total geographical area of the country. Out of this, major portion (more than 60%) of area exists in Rajasthan. The arid regions are characterized by wide variation in rainfall, soil type, irrigation facilities and micro-ecological conditions. The frequent draught leads to complete failure of crops very often, so much so that a good crop year has been observed to have a cyclic nature of 11 years. It is, therefore, not inappropriate to conclude that the major stay of rural economy in hot arid region is still animal husbandry. Livestock rearing is the major component of arid agriculture. In addition to provide quality nutrition in terms of meat and industrial raw material (wool, leather etc.), the contribution of small ruminants to arid crop farming through manure cannot be underestimated. Small ruminant-based animal husbandry also enhances the economic viability and sustainability of farming systems, particularly in rain fed areas. Arid region of the country is certainly better placed than the rest of the regions in terms of meat (>20% in terms of live animals) and fiber (>25%). That may be the reason that the people in this area suffer less from energy-protein deficiencies and hunger despite the lowest crop production. Animal husbandry in arid region has the added advantage of stability, round the year employment opportunity, equity distributive and being technologically simple (Chaudhry *et al.*, 1999).

Drought is considered by many to be the most complex but least understood of all natural hazards, affecting more people than any other hazard. Lessons from developed and developing countries demonstrate that drought results in significant impacts, regardless of level of development, although the characters of these impacts differ profoundly. Thought, drought is a normal feature of climate and its recurrence is inevitable, yet, there remains much confusion within the scientific and policy community about its characteristics. It is precisely this confusion that explains, to some extent, the lack of progress in drought management in most parts of the world (Wilhite, 2000).

Arid and semi-arid lands have probably never been under so much pressure, from climate variability, climate change and the demands of ever-increasing livestock and human population. Climate variability is a feature of many arid and semi-arid lands, though only the most protracted periods without rain can correctly be described as droughts. Protracted droughts lead to pressure being put on vegetation and soils through over-stocking, and on governments to provide food or financial assistance. People living in the areas prone to drought can become more self-reliant through being proactive rather than reactive in coping with drought. However, an essential prerequisite to achieving increased self-reliance and to reduce the impact of drought is to put a state drought policy in place and provide the necessary research and education infrastructure so that farmers, agribusiness and rural communities can better anticipate and cope with droughts (White, 2000).

As income and employment in the crop sector started diminishing, the non-crop sector, which included dairy and poultry, underwent a significant upward rise. With the demand for poultry increasing and production reaching 40 billion eggs and 1.2 billion broilers, this sector now employs around 1.6 million people. At least 80 per cent of employment in the poultry sector is generated directly by these farmers, while 20 % is engaged in feed, pharmaceuticals, equipment and other services required by the poultry sector. Additionally, there is a similar number of people who are engaged in marketing and other allied activities in the poultry sector. All the above illustrate thee point that we have a gigantic potential in all of these sectors, which are potent employment and income generators for the rural masses. With skewed income and agricultural holdings being a reality of the country's rural land holding structure, livestock, fisheries and dairy development quite clearly hold the key for providing employment and income to large segments of the underprivileged. Increasing the purchasing power of the rural and periurban masses through the aforesaid activities would ensure that they could considerably improve their consumption and nutrition basket.

In the speech delivered by Prime Minister Manmohan Singh at the 51st meeting of the National Development Council at Vigyan Bhavan in the national capital on June 27. 2005 emphasized- "The rate of growth of the economy has traditionally been a key target of our planning process...It is the single most important indicator of general economic improvement...The growth target for the Tenth Plan was set at 8.1 percent and the Mid Term Appraisal shows that performance thus far is well below this target, averaging 6.5 percent in the past three years.... A particularly disturbing aspect of our performance over the past several years is that agricultural growth has decelerated after the mid-1990s. Agriculture had grown at 3.2 percent from 1980 to 1996. It decelerated to 2.1 percent during the Ninth Plan. The cornerstone of the Tenth Plan strategy was a reversal of the declining trend in the growth rate of agriculture and with a target for agricultural growth at 4 percent. Unfortunately, actual performance of agriculture appears to have deteriorated even further and will possibly not exceed 1.5 percent during the first three years of the Plan...The periodic failure of the monsoons in the last few years is certainly a contributory factor but the problems with agriculture go beyond weather...For overcoming stagnation of agricultural growth, we need to act on several fronts. We need to focus attention and increase investments in the entire chain of activities related to agriculture - the supply of inputs and credit, diversification of crops, better production practices and improved post-harvest management...Other critical requirements for agricultural dynamism include new generation technologies and an effective extension machinery for delivering technological products to farmers. There has to be a sharper focus on strategic research for evolving the needed technologies, a task that can be assigned to the agricultural research system of the ICAR (Indian Council for Agricultural Research) and the SAUs (state agricultural universities)...Indian agriculture in future must move from the traditional grain based strategy followed in the past towards diversification, emphasizing horticulture, poultry and livestock. This transition poses new challenges, including new institutional arrangements."

In 1950-51, the contribution of agriculture sector to the national GDP was 50.5% with the share of animal husbandry as 15.5%. The share of agriculture went down to 20.5% by 2003-04, and the animal husbandry still contributing 1/3rd of it. The current contribution of animal husbandry is estimated around Rs. 200,000 crores annually. The market value of Indian livestock is estimated at Rs. 65,000 crores exceeding the value of food grains produced, annually. Salient features of Animal husbandry sector of India are:

- India has about 16% of cattle, 57% of buffalo, 17% of goats and 5% of sheep population of the world.
- India ranks first in respect of cattle and buffalo, second in goats, third in sheep and sixth in poultry population.
- The livestock sector employs 30 million in principal and subsidiary sectors of which women make up 71% of the labour force.
- The contribution of livestock and fisheries sector to the total GDP during 2003-04 was >7%.
- The total export earnings from livestock, fishery and related products was > 10,000 crores in 2003-04.
- The landless, marginal and small farmers have more than 80% of the bovine population with operable area of only 57%.
- There are 6.7 million fisher folk in India.
- Fisheries and related activities provide livelihood to over 10 million people. The projected job generation by the end of 2012 is expected to be about 12 million.

Livestock rearing is the major component of arid agriculture, with particular reference to the state of Rajasthan. In addition to providing quality nutrition as milk, meat, eggs etc. and industrial raw material as animal fiber, leather etc., the contribution of livestock to arid crop farming through drought power and manure also cannot be underestimated. Animal husbandry also enhances the economic viability and sustainability of farming systems. It diversifies production and management options; increase total farm production and income. Stable and consistent growth rate in animal husbandry sector will help in increasing employment and bring about income redistribution in favour of small and marginal farmers and landless labourers. It is required therefore to make Rajasthan a leading player in livestock product markets through sustained and all-round improvements in quality and efficiency by enabling the Small Producer to gainfully participate in the process of growth and modernization of the livestock sector and simultaneously ensuring the ecological sustainability of Livestock Sector during growth and modernization. Growth in animal husbandry sector will help in increasing employment and bring about income redistribution in favour of small and marginal farmers and landless laborers. The sector has proved as a means to provide-

- stability with a consistent growth rate of over 6% per anum,
- round the year employment opportunity with >50% of total house hold income in arid region as against 22.5% of national average,
- equity distributive as indicated by the fact that the share of the bottom 60% house holds in the ownership of bovine has increased from 58.8% in 1982 to 65.7% in 1992,
- Technologically simple vocation as traditionally, the arid farmers keep livestock in proportion to the 'free' crop residues and family labour available in their own household production systems and convert these into food, fuel and farm power-making each house hold a virtual self contained production system with no purchased inputs and little marketed outputs. All this makes the arid livestock farming a technologically simple enterprise to be followed as a tradition.

Strengths

- Most important economic activity in arid zone (more than agriculture)
- In other agro-climatic zones it is next to agriculture
- >75 rural house holds have livestock as an important component
- Average income from livestock 30-50% whereas reaches 60-80% from dairying
- 90% of all labour is from women
- Women have no say in its appropriation
- Ownership highly dispersed in ESWS
- Minimum credit-NABARD finances only <25% to this sector
- 80% rural house holds
- Ranks 3rd in milk production in the country, at very close heels of Punjab, which stands second.
- Produces 9% milk, 40% wool and 10% meat of the country
- Asset worth Rs. 25,000 crores
- Draught proofing technology
- Traditional
- Women empowering
- Labour intensive
- Rural self employment
- Technologically simple & adaptive
- Production worth Rs. 20,000 crores

Livestock Asset of the State

2003

SPECIES	IN LACS	TOTAL VALUE IN LAC Rs.	SURPLUS VALUE IN LAC Rs.
CATTLE	109	10,000,00	03,500,00
BUFFALO	105	11,000,00	04,000,00
SHEEP	101	01,750,00	00,600,00
GOAT	168	02,000,00	00,700,00
CAMEL	005	COMPARATIVELY LITTLE	
OTHER	005	COMPARATIVELY LITTLE	
TOTAL	492	#25,000,00	#08,800,00

Worth Of Milk Production 2002-3

SPECIES	IN '000 TONS	VALUE IN LAC Rs.
COW	2450	2000,00
BUFFALO	4800	4800,00
GOAT	0850	0650,00
TOTAL	8100	7450,00

Worth Of Poultry Production 2002-3

NUMBER	IN LACS	VALUE IN LAC Rs.

POULTRY	0075	004,50
EGGS	6000	060,00
BROILER	0900	045,00
TOTAL		109,50

THREATS TO ANIMALS IN ARID ZONE:

1. **Climate:** Hot and dry climate used to be considered as a safe climate from the point of view of infectious diseases. Nevertheless, recently some of the diseases of humid climate like those of PPR, tuberculosis, contagious mastitis, schistosomiosis, high concentration of internal parasitism etc. have been recorded in the arid region also. Heat stress/exhaustion/stroke have become quite common. Conversion of hot dry climate into hot humid climate after incorporation of a vast area of western Rajasthan under canal/well irrigation is also a predisposing factor to many hitherto unreported stress (Singh *et al.*, 1994), infectious (Mittal, 1987) and parasitic diseases (Pathak, 1997).

2. **Distant pastures:** With degradation of earst while pastures (Mertia, 1987), half hearted attempts of their conservation and drastic reduction of Common Property Resources (CPR), the pastures have gone far too away from the habitations. Animals still on complete/partial range rearing practice are more prone to nutritional deficiencies including protein-energy as well as mineral-vitamin (Fakhruddin. 1987). Furthermore, prolonged timings when the animals are at-pasture predisposes them to attack of several insect vectors/mechanical transmitters of diseases (Gahlot, 1997).

3. **Prevalence of important diseases:** Arid zone is registering continuous and increased prevalence of many epidemiologically important diseases of animals, which is a serious threat to animal husbandry in this area. Diseases like FMD, rabies, contagious ecthyma, sheep and goat pox, tuberculosis, Johne's disease, enterotoxemia, mycoplasmal infections, coccidiosis, brucellosis, anthrax, rickettsial and chlamydial diseases, nematode infestations, mange, pica (Kishore, 1998), deficiency of Vit. A and D (Fakhruddin, 1987), B1 (Tanwar *et al.*, 1983; 1994) etc., deficiencies of calcium, phosphorus, zinc, iron etc. are not only prevailing unabated but also are registering an upward trend. High incidence rate of subclinical mastitis has also been reported from this area (Singh *et al.*, 1999).

4. **Scarcities of feed and fodder resources:** There is an evident scarcity of feed and fodder resources in arid zone. Some of the factors responsible for this deficiency, such as degradation of pastures, drastic reduction of CPRs and persistent drought resulting often into complete crop failure and consequently complete crop residue failure. Most of the feed and fodder ingredients are now being imported from other areas and states. Some of the dietary ingredients have replaced the earst while *Lasiurus sindicus* straw and *Zizyphus numularia* leaves almost to the extent of 80%. Similarly, the traditional ingredients of concentrate ration, such as, sesame cake and Guar (*Cymopsis tetragonoloba*) seeds have almost been completely replaced by cotton seed/ground nut/mustard cake, legume churi (coarse ground industrial by product), DORB, wheat bran etc. This switch over has resulted into higher incidence of metabolic (production) diseases. Production diseases were earlier considered to be related to only high producing exotic/cross bred animals, particularly cattle and buffaloes. Their incidences in the indigenous small ruminant animals have proved that dietary factors have become important in this group also.

5. **Deficiencies:** Several deficiencies have been identified in the animals of arid zone (Dongre, 2000) because of evidence of existence of deficiency, deficiency as the cause of the disease and cure or prevention by correction of the deficiency. Energy and protein deficiency results in to pica. Copper, cobalt selenium, zinc (Singh *et al.*,1994), iron and iodine are some of the trace minerals resulting into general conditions like anaemia, retarded growth, reproductive disorders, pica (Kishore, 1998) and certain specific conditions suggestive of deficiency. Apart from these, deficiencies of vitamins A, D_3, E, B_1 (Tanwar *et al.*, 1983, 1994) and C have also been identified.

6. Toxicity: Cyanide, sodium chloride, nitrate and nitrite poisoning have been reported to occur in this zone since long (Sharma and Gahlot, 1997). Newer toxicity includes those with pesticides/farm chemicals, feed additives, drugs, environmental pollutants etc. (Radostits *et al.*, 1994).

Pesticides/farm chemicals: With frequent use of pesticides/farm chemicals in agriculture in this zone, particularly in the areas under irrigation, risk of poisoning of livestock has increased many folds. This is mainly because most of the domesticated animals in such areas are reared as a component of mixed farming system. Accidental access to insecticides/pesticides/farm chemical is the main cause of poisoning in not only animals but also human beings. Chlorinated hydrocarbons like chlordane, toxaphene, heptachlor etc., organophosphorus compounds and carbamates like endosulphan, monocrotophos, chlorpyriphos etc. and chemicals like urea are among the commonest poisonings. Seed dressings, rodenticides and herbicides are another class of miscellaneous chemicals exposing animals accidentally. Pesticides like melathion, asuntol, pyrethrins, amitraz etc. are also used in control of ectoparasites of animals. Application of these compounds in the concentrations and applications higher than the recommended ones often results into toxicity (Radostits *et al.*, 1994).

Feed additives: Feed additives like monensin, tiamulin, salinomycin etc. are not in use currently in this area. The only feed additive, particularly to improve the quality of roughage, is urea. Accidental overdosing of urea occurs as a result of miscalculation of the concentration. Any amount of urea over 1-2% may cause urea toxicity in ruminants.

Drugs: With the availability of several newer drugs and compounds, narrow therapeutic index, wide spread contraindications, anaphylactic reactions and adverse drug reactions have increased the risk of drug toxicity in animals. Ivermectins, antibiotics, antiprotozoan drugs like dimenazine, quinapyramine etc.

Environmental pollutants: The major environmental pollutant affecting the health of farm animals, particularly cattle, is plastic and polythene. *Per se*, there is no toxicity of polythene, but owing to its non-biodegradable property, it acts as a non penetrating foreign body in the rumen of ruminants, leading to complete cessation of fermentatory activity and motility of rumen. Such animals necessitate surgical intervention in the form of rumenotomy. Recovery in such animals is also comparatively slower due to long standing malnutrition and debility. Other environmental pollutants include industrial waste, lead, arsenic etc. Due to influx of feed and fodder ingredients in the arid zone from other areas, phytotoxins and mycotoxins have been frequently identified in feed and fodder. These toxins not only affect health directly, but also production and reproduction of farm animals. Prolonged and poor storage conditions have been identified as the most important contributory factors to mycotoxicosis. Apart from direct effect on the health of the animals, these have been found to cause hyperthermia and precipitation of the production diseases.

<u>Strategies-Technology options</u>

a) ***Germplasm:*** The state is endowed with vast livestock populations having wide genetic diversity suitable for milk, meat and fiber production and draft power. While giving due emphasis for their genetic improvement for efficient production there is need for conservation of this valuable germplasm. Critical evaluation and classification of various breeds may be carried out concurrently but germplasm conservation works need not to wait for detained classification.
b) ***Feed resource:*** In recent decades, growing concern has been expressed about the large and expanding gap between feed and fodder resource availability and demand to be an alarming 50-80% of the requirement. With such a glaring shortage of feed and fodder, how can an increasing livestock population also increase productivity and total production at respectable rates? The reasons may be-farmers do nor feed at scientific feeding rates; resources actually available as grazing, CPRs, forests and crop residues are greater than estimated. Nevertheless, it would be patently wrong to underrate the seriousness of the feed and fodder resource problem. It is difficult to find immediate solutions and therefore, research and development wings need to address this imminent problem urgently.
c) ***Livestock Management-Ecological aspect:*** For the livestock policy, it makes best sense to help generate alternatives that reduce the pressure on the rural people to pursue livelihood strategies detrimental to

their habitat and natural resources; and promote symbiotic and synergistic relationships between local communities and their environment through participatory natural resource management.

d) ***Animal Health Management***: Another critical constraint is the wide spread presence of a variety of animal diseases and the state's failure to eradicate/control them. This may not only affect livestock/product export, but also results in massive economic losses. Establishment of efficient animal disease surveillance, monitoring and forecasting on the state and regional levels and development of effective and economic vaccines and biological products using modern technologies to check the onset and spread of animal disease and pests will go a long way in supporting the growth of this sector.

e) ***Breeding Management*** through restructured A.I. programme comprising of input generation and delivery system.

f) ***Animal Production system***: The state of Rajasthan has well-established cattle, buffalo, sheep, goat, camel and poultry productions. The research and development support need to be designed in a way that there is blending of the features of advanced input intensive technologies with traditional production systems. Backyard production systems/small holder livestock production farming particularly indigenous cattle, camel, donkey, poultry and goat need special attention. Pig farming needs reintroduction into the state.

g) ***Product processing***: HACCPS endorsed by ICMSF are required to be followed particularly in the meat processing industry.

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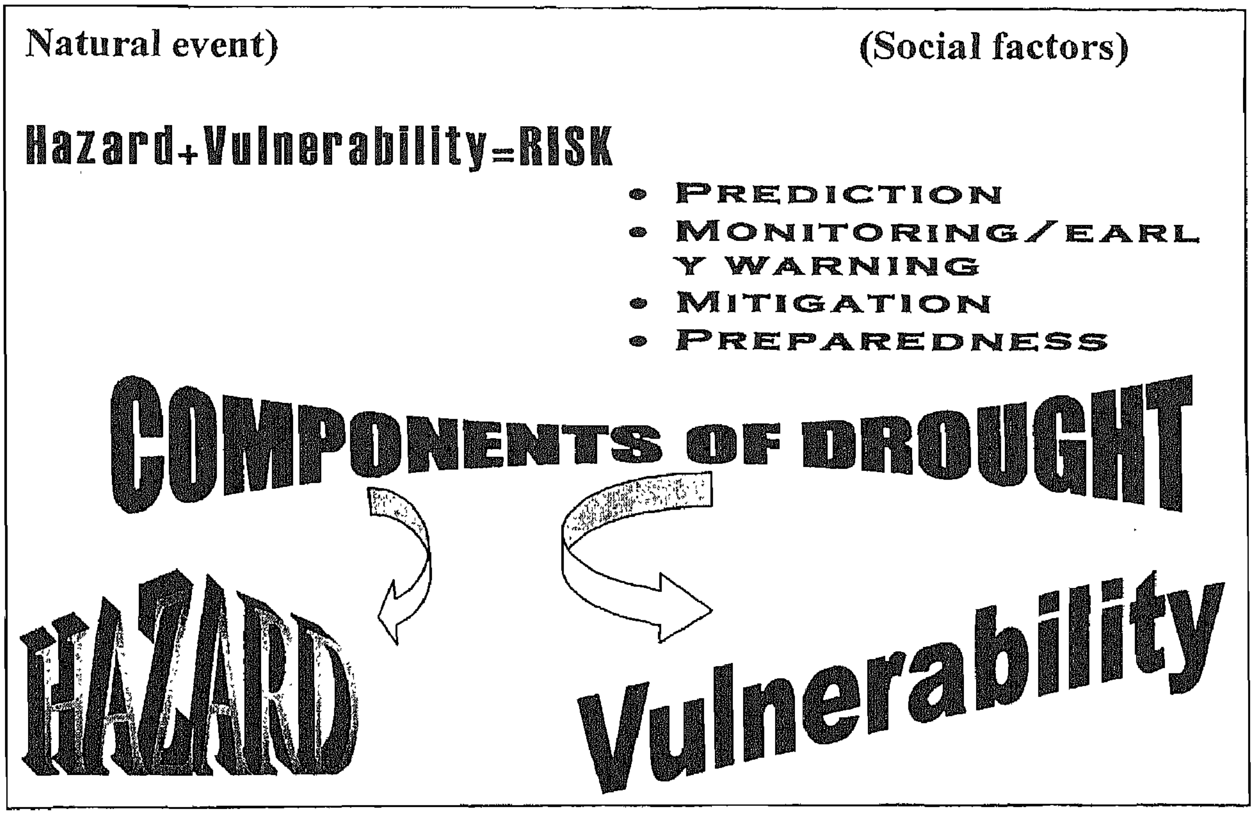

FEEDING PRACTICES OF LIVESTOCK DURING DROUGHT CONDITIONS-IMPORTANCE OF FEED SUPPLEMENTS

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Livestock plays a crucial role, contributing through milk, meat, wool and their products. Materialization of optimum utilization of feed and fodder resources to combat scarcity, needs practical strategies through planners to enhance livestock productivity in India, and other developing countries. Livestock productivity is becoming a major consideration for many developmental programmes. According to FAO estimate of 2002., the country had 219.6 million cattle, 80.6 million buffaloes, 123.5 million goats, 58.2 million sheep, 17.5 million swine and 413 million poultry. Population figures indicate that Indian cattle, buffaloes, sheep and goats constitute 16, 54, 5 and 21% respectively of world population. Put together these livestock contribute 1830 billion rupees to GNP, which in turn is 32% of 27% contributed by the agriculture.

In arid zone traditional rural wisdom prefers livestock based agricultural practices as compared to crop farming. Most of the research findings with holistic perception in the field of agriculture and animal husbandry also confirm it. The recent survey carried out by NIANP, Banglore indicate that there is shortage of 45% of dry roughages, 44% of concentrates and 38% of green fodder (Anon. 2001-02). Arid zone is facing continuous drought since last four years. However, the recent drought (2002-03) is the severe most due to cumulative effects of preceding years. When crop fails, livestock serves as a ready source of revenue for the livelihood of arid farmers. Thus livestock is the backbone of rural economy in the Thar Desert.

As per the latest livestock census (2003), Rajasthan state harbours 49.1 million livestock, out of which arid zone (12 districts) livestock population is ......2...60 million. The native livestock breeds of arid zone have inherited through generations' adaptability to adverse climatic conditions of the hot desert.

During drought the first and foremost branch which needs utmost attention is animal nutrition or the feeding management.

Feeding management

Due to the acute scarcity of feed and fodder during drought the utmost importance is given to the feeding component. Dried roughages provides bulk to the belly and meets 70-80% supply of dry matter and total digestible nutrients (TDN) required by cattle, sheep and goats. Failure of the monsoon is the main reason responsible for drought in the country. Arid areas where mostly rain fed agriculture is practiced are most prone to fodder scarcity than others.

Traditionally, the arid zone farmer conserves and stores the bajra straw, grasses etc., sometimes blended with legume crop byproducts of mung and moth in a typical dom shape storage, called "Bhanwariya" in local language. The walls are constructed using less edible crop byproducts and vegetation. These fodder stores are opened during drought to maintain the livestock for few months. During present continuous drought situation livestock keepers have already exhausted stocks long back and have nothing to feed to the livestock.
Status of feed and fodder resources: There is an evident scarcity of feed and fodder resources in arid zone. In a case study,it is observed that in villages of Shergarh tehsil on an average had a deficit of fodder ranging from 21 to 28%(Mathur et al.,2003) Where as in Solankiyatala and Sai villages of Shergarh tehsil the deficit was to the tune of 80% %it clearly repeated that due to cumulative effect of drought from year 1998 to 2000, and 2002, there is sharp decreased in livestock population. Livestock decreased by 65 and 62% in the above villages due to

lack of feed, fodder, sale of animal, high morbidity and mortality rate.In both the villages the livestock owner has no store of feed and fodder due to continous drought. Fodder is being transported from neighboring state and made available to them on cost by local bodies, but the quantity and frequency is irregular. In the common grazing land (CGL) the edible grasses, shrubs/ bushes has almost disappeared. (Mathur et al., 2002).Some of the factors responsible for this deficiency, such as degradation of pasture, drastic reduction of CPRs and persistent drought resulting often into complete crop failure and consequently complete crop residue failure.Most of the feed and fodder ingredients are now being imported from other areas and states. Some of the dietary ingredients such as ground nut roughage and wheat straw have replaced the erstwhile *Lasiurus sindicus* straw and *Zizyphus numularia* leaves almost to the extent of 80%. Similarly, the traditional ingredients of concentrate ration, such as, sesame cake and Guar (*Cymopsis tetragonoloba*) seeds have almost been completely replaced by cotton seed/ground nut/mustard cake, legume churi (coarse ground industrial by product), DORB, wheat bran etc. This switch over has resulted into higher incidence of metabolic (production) diseases. Production diseases were earlier considered to be related to only high producing exotic/cross bred animals. Their occurrence in the low producing indigenous animals has proved that dietary factors have become more important than the high production. Grazing livestock are commonly infested with various endo parasites leading to clinical or sub clinical manifestation and enormous lost to livestock owner both direct as well as indirect as. Digestibility of nutrients also reduces lowering feed utilization. Due to pathogenic changes the animal become weak with retardation in growth, production and working ability (Panda and Baidya 2004).

Deficiency of nutrients: Several deficiencies have been identified in the animals of arid zone (Dongre, 2000) because of evidence of existence of deficiency, deficiency as the cause of the disease and cure or prevention by correction of the deficiency. Energy and protein deficiency results in to pica. Copper, cobalt selenium, zinc (Singh et al, 1994), iron and iodine are some of the trace minerals resulting into general conditions like anemia, retarded growth, reproductive disorders, pica (Kishore, 1998) and certain specific conditions suggestive of deficiency. Apart from these, deficiencies of vitamins A, D, E, B, (Tanwar et al, 1983, 1994) and C have also been identified.

Under such condition meeting of fodder demand by transportation of wheat straw or paddy straw etc., from neighboring states becomes a major task. Moreover, the roughages like wheat/paddy straw are of very poor nutritive value in terms of digestible crude protein (DCP) and total digestible nutrients (TDN). These straws as such are unable to meet even the maintenance requirement of livestock and thus lead to higher rates of nutrition related health problems. Similarly, the conventional concentrate feeds like oil cakes, legume and cereal grain or their byproducts are available at unaffordable high prices and becomes out of reach. During this period resources like unconventional feeds, non protein nitrogen and mineral mixture will play an important role when utilized judiciously.

Therefore, during drought following techniques for livestock feeding will be beneficial for the well being of animals.

1. Preparation of ration with urea-molasses for immediate feeding (Per cattle/day).
2. Wheat/paddy straw 3.0 kg.
3. Molasses 300 gms.
4. Urea 30 gms.
5. Vitamin Mineral Mixture 20 gms.
6. Common salt 20 gms.

Procedure of Feeding

In a container dissolve 30 gms urea in half litre of water and add 300 gms molasses, stir it with a stick homogenously. Now spray evenly this urea molasses solution on straw and then also spray on straw vitamin mineral mixture with common salt. Finally using both hands mix the ingredients with straw thoroughly. Ration is ready to be fed to livestock. For making ration of 100kg straw we require one kilogram urea and ten kilogram molasses. This ready to fed ration is very palatable to animal and is consumed immediately.

Urea treatment of straw:

Wheat and paddy straw is crop residues lift after harvesting the grains from crops. These straw forms the main bulk of roughages for cattle during drought. These cereal roughages are poor in nutritive value, with almost 0% digestible crude protein. Due to high lignin content the palatability is also low. High oxalic acid content in paddy straw affect calcium absorption. So when as such dry straw is fed to cattle the maintenance requirement is not met with. Therefore, with dry straw either come green fodder or grain/cake is mixed and offered to cattle. But under drought circumstances, these are not available with livestock keepers. Keeping this in view the alternative to be adopted is 3% urea treatment of the poor quality straw with 50% moisture level and stored under cover for 21 days. This urea treated straw can meet the maintenance requirement of the animal to a large extent.

Procedure of urea treatment of straw:

Material required: For 100 kg straw we require 3.0 kg urea, 40-50 litre water, buckets, polythene sheet or used empty polythene bags.

Method:

- First spread 25 kg straw layer on clean pucca cemented floor in 3x5 feet area.
- Dissolve 3.0 kg urea in 40 litres of water.
- Now spray 8-10 litres of urea mixed water on spreaded straw and compress evenly with feet by 2-3 persons.
- Over the spreaded straw similarly put three more layers of about 25 kg straw one over another layer. While putting on layer of straw over another each time spray 10 litre of urea dissolved water and press it with feet to minimize air entrapped between straw.
- Now cover the treated straw with polythene sheet or bags in a air tight manner so that near anaerobic condition can be maintained.
- Put some weight over the covered treated straw like stone slats etc. to keep polythene intact.
- After 21 days the enriched treated straw is ready to feed the livestock.
- This treatment increases the nutritive nature of straw in terms of protein and energy many folds. Since the lingo-cellulose bond is broken, the protein and cellulose of the straw in addition to urea nitrogen will be made available to animal.

Precautions:

(a) Urea mixed water should be used immediately and must be kept away from livestock because; as such it will be highly toxic to animals.

(b) Spray urea mixed water evenly on straw.

(c) Feeding of Urea treated straw should be increased slowly day by day in the ration of animals to develop its palatability.

Commonly used poor quality roughages in India

Crop Residues and agro industrial by products			
1.	Wheat straw	12.	Sorghum stover
2.	Rice straw	13.	Millet stover
3.	Bajra straw	14.	Cotton by products
4.	Masoor straw	15.	Cotton straw
5.	Sugar cane tops	16.	Fruit canning waste
6.	Corn stover	17.	Rice hulls
7.	Corn cobs	18.	Sugar cane bayasee
8.	Oat straw	19.	Cotton seed hulls
9.	Sunflower stover	20.	Coffee beanhull
10.	Cassava wastes	21.	Soyabean straw
11.	Cassava leaves	22.	Banana pseudo stem

It is an established fact that these poor quality roughages are less palatable and nutritionally poor than cultivated grasses or legumes commonly used in different animal production in their nutritional quality. Among the several roughage sources available cereal straws with an annual total availability of about 250 million tonnes (Mudgal ad Pradhan, 1989) received maximum attention for improving their palatability and nutritive value because of their huge availability. The significance of improved animal nutrition on productivity and its continuing constraint on prevailing animal production systems has been repeatedly focused across the developing countries (ILRI 1995). Inspite of huge gap existing between availability and demand for dry matter energy and protein at national level for feeding different species of livestock, still in states like Punjab and Haryana cereal straws more specifically rice straw is being burnt in the fields contributing to loss of valuable energy source to the national pool. Under global context wheat straw (25.3%) is the most abundant crop residue followed by rice straw (22.8%), corn stover (15.8%), barley straw (8.3%), sugarcane tops (8.1%) and sugarcane by products (6.3%) as reported by Han and Garett (1986). Asia is producing about 46% of the world supply of crop residues; therefore Asian Animal Nutritionists have paid more attention to improve the nutritive value and utilization of crop residues as animal feed in relation to other regions. Ninety two percent of rice straw and thirty four percent of the wheat straw are produced in Asia.

Many methods of treatment have been exhaustively investigated before accepting urea ammoniation as the most potential method for field scale application in most of the Asian countries. Urea treatment can be done in different ways, depending on the local conditions and preferences but some rules can be given regarding concentration of urea, duration of treatment, amount of water to be used and way of stacking.

Table: Chemical composition of lignocellulosic by product

Nutrient	Wheat straw	Rice straw	Sugarcane tops	Oat straw	Rice hulls	Corn stover
Cellulose	36.3	37.0	25.7	36.5	42.0	31.0
Hemicellulose	24.4	21.1	28.8	31.8	18.0	28.5
Holocellulose	60.7	58.1	54.5	68.3	60.0	59.5
Lignin	9.7	8.2	7.5	8.5	26.0	13.0
Crude protein	2.6	2.1	6.3	3.4	2.0	6.0
Ash	5.8	8.4	5.0	3.6	12.3	7.0

Chopping of straw:

For feeding livestock always offer chaffed fodder. Chopping improves digestibility and avoids nutrient wastage.

Addition of leguminous crop by products:

Feeding of wheat/rice straw by mixing with leguminous straw e.g., gram straw, groundnut crop byproduct or masoor straw will improve nutrient availability and digestion of the livestock.

Supplementary feeding:

1. **Use of urea molasses mineral blocks :**

   Supplementation of urea molasses blocks as lick along with straw feeding is recommended during drought. Block contains urea, molasses, minerals along with some grain/cakes and a binder. Animals meet out their requirement of energy, protein and minerals by licking these blocks. The blocks available in market are compact, normally weights around 3 kg. And occupies less space and are easy to transport.

2. **Providing vitamin "A" doses :**

   Provision of vitamin "A" sources in animal ration is essential. Green fodder contains carotene which is being converted into vitamin "A" in animal body. However, during drought green fodder is not available to livestock and thus animal shows symptoms of vitamin "A" deficiency which are predominantly as under:

   - Lachrymal discharge
   - Loss of resistance power to diseases.

- Frequent diarrhea.
- Corneal opacity.
- Newly born calves, lambs are blind.

Treatment:

Provide vitamin A injection at bimonthly interval and/or in ration add vitamin A containing mineral mixture.

Vit A 440 *I.U.*/kg B.wt

Parentral injection of aqueous solutions than oily solutions

Excess doses cause – rarefaction of bones and fetal abnormalities

Control daily requirements

Vit A	30 *I.U/kg B.wt*
Carotene	70 *I.U.*/kg B.wt

3. **Cheaper and balanced concentrate for lactating animals**

Tumba (*Citrullus colocynthis*) seed cake of arid zone has been evaluated as feed to provide protein and some minerals. This is available in market at about one fourth price of the conventional cakes. Tumba seed cake can be incorporated in concentrate upto 25% level, reducing cost of concentration by 20%. To this 15-20% grinded *Prosopis juliflora* (English babool) pods can be added as energy source which are also very cheap and available locally.

4. **Feeding of Mineral mixtures and common salt**

Feeding managers of animals should have mineral bricks and common salt, so that deficiency of minerals and common salt may not occur.

5. **Deworming :**

Animal should be dewormed with broad spectrum anthelmentic thrice yearly. In case of ectoparasites: spray/ dusting should be done at regular intervals with ectoparasiticide. These simple treatments will increase the availability of nutrients to livestock.

Case study:

Survey was conducted in four villages during drought, namely, Sointra, Shergharh, Sai and Solankiyatala of Shergarh Tehsil, district Jodhpur of western part Rajasthan, India. Data were collected with a specially designed interview schedule, group interview, field animal parameters and through participatory rural appraisal. A cross section of the population living in scattered settlement called "Dhani" were interviewed.

It is observed that in village Sointra and Shergarh on an average had a deficit of fodder ranging from 21 to 28% and that of concentrate it is from 48 to 79 percent. While in Sai and Sdankiyatala the fodder and concentrate deficit is upto 80%. The average grazing distance traversed (kg/day) in cattle varied from 1.8 to 4.8 km, sheep it was as high as 10.0 kms while goat traversed between 4 to 6 kms. Incidences of diseases were classified systemwise viz gastrointestinal(GIT), respiratory(RIT), reproductive and skin. The occurrence of gastrointestinal diseases was highest (29%) in Sointra, reproductive (26%) in Shergarh, and skin (28%) in Sai followed by Solankiyatala (25%) was recorded.

Reproductive parameters studied among the 20 households surveyed in each village depicts that age of maturity in cattle were higher in Sointra and Shergarh villages as compared to Sai and Solankiyatala which was 48 and 41-35 months respectively. The reason understood may be that minimum gastrointestinal diseases were reported in these village reflecting comparatively good feeding. The other reason may be the percent population of cattle in surveyed households was very less (7 to 16%) of the total livestock population while sheep and goat population was more than 80% of the total livestock numbers. Anestrous cases were higher (15-25%) in Solankiyatala village. Morbidity rate was highest in Shergarh village due to GI disturbances 29%

followed by Sai village due to skin 28%, then in Shergarh with reproductive disorders 26%, Solankiyatala with skin affection 25% and then of respiratory infection 22% in Sointra village. High GIT and RTI probably is responsible for higher age of maturity in cattle(Mathur et al.,2004).

Thus, it is concluded that in the Surveyed villages there is scarcity of feed and fodder. The nutrient requirement of the livestock needs to be meet up by balanced feeding and to build up the resistance of livestock against diseases. Water channels needs to be constructed in CPR with routine water supply connection. Planning is required to improve the common properly resources by resowing grasses, shrub and top feeds.

Feeding management of livestock during drought can be summarized as follow:-

Preparation of ration with urea-molasses for immediate feeding

Urea treatment of straw

Chopping of straw

Addition of leguminous crop by products

Supplementary feeding: -

- Providing Mineral vitamin mixture
- Use of urea molasses mineral blocks
- Providing vitamin "A" doses
- Cheaper and balanced concentrate for lactating animals
- Mineral bricks and common salt

Deworming with broad spectrum anthelmenthic.

Observations recorded during drought condition in arid villages:

- Acute scarcity of feed and fodder
- stored fodder has been exhausted long back
- no feed fodder available in community grazing land
- daily grazing distance has increased significantly
- even the population of *caparis decidua* reduced considerably
- health of arid livestock adversely affected
    - weak
    - debilated
    - consuming inanimate objects
    - ruminal atony
    - pneumonia
    - skin infestation
    - abscess around neck

Reproductive disorders:

- increase in age of maturity
- abortion
- prolapse
- anoestrus

Sequelae: high morbidity and mortality rate

Possible measures:

- Maintenance requirements of livestock need to be met :suggested and demonstrated poor quality fodder enrichment and supplementation with balanced concentrate.
- Veterinary assistance needs strengthening
- Water points need to be maintained
- Fodder transport and distribution needs improving from near by state: straw- mostly having 0.00% DCP and low TDN

- Common Grazing Lands need improvement
- *People should be encouraged to grow fodder on their land*

Livestock Parameters to **be studied during drought** condition:

- Feed resources available
  - fodder deficit
- Grazing distance traversed
- Occurrence of diseases
- Reproductive parameters
  - Age of Maturity
  - Anestrous
- Morbidity disease

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SUPPLEMENTARY FEED BLOCKS AND NUTRIENT MIXTURE-AN APPROACH FOR BALANCED FEEDING DURING DROUGHTS

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Rajasthan covers 3.42-lakh sq km area, which makes 10.4 % of total geographical area of our country. Its 62% area is under hot desert (arid region) consisting of 12 districts in southwestern region. Annual rainfall in the state varies from 100-120 mm in the Jaisalmer district to about 1000 mm in some parts of Chittorgarh, Jhalawar and Kota districts. About 70 per cent of rural population depends upon agriculture and allied activities. Agriculture becomes a gamble, due to erratic and low rainfall, especially, in arid region and thus animal farming became a major occupation for the livelihood of the rural population particularly in the 12 western arid districts of the state. A study by the National Council of Applied Economic Research (1990) reported that revenue from milk sales alone accounted for 22 per cent of the family income in the state, as this state contributes 10% of the total milk produced in the country. The animal husbandry contributes 19 per cent of the state GDP. The livestock sector is more labour intensive than crop cultivation and accounts for a major share in rural employment with 4.5 per cent annual growth as compared to 1.75 per cent for all sectors and 1.1 per cent for agriculture.

Most of the livestock population in the state is range managed, except during monsoon period, thrives upon dry grasses in the ranges and pastureland, and crop residues in the fallow lands. These crop residues are very low in essential nutrients including fermentable energy, protein, minerals and carotene, which is a precursor of vitamin A. The problem of mineral deficiency is further aggrieves due to high calcium and very low phosphorus content of the crop residues. Calcium-phosphorus imbalances adversely affect the availability of calcium as well as the phosphorus. The dry fodder scarcity is as another problems. Even in the normal rainfall years, the dry fodder and green forages availability, respectively is 30% and 59% of total requirement of the state. This situation is further worsens during drought years. Under such circumstances crop residues like straws and stovers are imported from the neighboring states. During normal year their productivity and survivality during scarcity and drought conditions can be ensured by supplementation of essential nutrients to these animals.

There are different means of supplementation of essential nutrients to the livestock, which are fully or mainly thrive upon roughages diet. The compact feed block is one of the most appropriate means to do so. Beames (1963) in Australia introduced the concept of feeding compact feed blocks, comprised of molasses and urea. Later on this technology was refined and brought to the field with its main objective to improve productivity of the cattle by Leng and Preston (1983). This pioneer work was initiated in India, and now, with the technical assistance of FAO, the technology in use in more than 30 countries. Sansoucy and Coworkers had given detailed procedure of production of compact feed blocks. They have also categorized the blocks produced of different formulations. Molasses has been used as a source of fermentable energy. The molasses of above than 85-brix value should be used for making quality blocks. Urea was used as a source of fermentable nitrogen. Its continuous supply, through feed blocks, increased intake of straw by 40% and digestibility by 20% in cattle. The cereal bran is used as an absorbent of the moisture present in the molasses. It also gives structural stability to the blocks. They further opined that the blocks could act as an excellent carrier of the common salt, as well as essential minerals. The gelling agents like magnesium oxide, bentonite, calcium oxide, calcium hydroxide and cement were used for compaction of the blocks. The blocks can be made by hot, warm or cold possesses. Sansoucy et al (1986) had described the cold process in details. He opined that the calcium oxide can be replaced by cement, but before use, it should be mixed with 50% water. Quick lime has also been used in block production, but it resulted into harder blocks than blocks comprised of cement. Cement or its by-product, the cement kiln dust, used as a mineral supplement in Canada, Italy, USSR and USA, have not shown any adverse effect when fed up to 1% to 3% of the total dry matter, but, USDA has restricted the use of cement kiln dust as it could result in the deposition of heavy metals in animal tissues. Van Houtert and Leng (1986) showed that the addition of small amount of soluble calcium salt of long chain fatty acids increases efficiency of the use of fibrous feeds.

Sansoucy *et al* (1986) pointed out that the hardness of block affects its rate of intake. High urea blocks also reduces intake. He recorded that the block feeding increased straw consumption. *In sacco* dry matter digestibility in sheep improved from 42.7 to 44.2% in the sheep offered the compact feed-block. Total fatty acids in rumen were increases when lamb consumed the blocks. The increase was more pronounced in propionate and butyrate production. Feeding cake has also resulted in increase in average daily body gain in ruminants. Sansoucy *et al* (1986) opined that the animal become much more efficient in using the available nutrients. In Ethiopia it has been reported that by feeding the feed block, the level of feeding concentrates can be reduced by half without adversely affecting the milk production. Recently, El-din *et al* in (1996) have also reported that the blocks can be used to partially substitute concentrate fraction of the diet to maximize utilization of cotton stalk in sheep. Such type of blocks has been found to be much useful as scarcity feed supplement, and can be used as survival feed during calamities. Dr S. K. Ranjhan (1993) documented that during volcano eruption at Mt Pinatubo in Philippines in 1991-92, more than 800 cattle and buffaloes were given such type of urea-molasses mineral blocks as relief assistance for a period of 1-yearas scarcity feeds.

In India, feed block technology was first introduced by NDDB, which was followed by state's cooperative dairy federations' cattle feed plants. It was followed with development of appropriate formulations of such blocks at HAU, Hisar, PAU, Ludhiana, IVRI, Izatnagar and also at RAU, Udaipur. But all these formulations included one or other inorganic binder and the product was dried by chemical process. In recent past, some work on development of appropriate formulations and process technology using locally available feed resources and gadgets, which can be fabricated by local artisans, was initiated. George Kunju and Ram (1986) have conducted extensive studies on development of formulations and production technology of compact feed block, known as urea-molasses mineral blocks (UMMB). They recorded that utilization of crop residues can be augmented by supplementation of source of nitrogen, energy and mineral which increase the microbial protein synthesis in the rumen and indicated that the buffalo feeds can be economize by feeding urea molasses blocks and feeding of concentrate mixture can be curtailed by 40%, with little quantity of cotton seed meal in block supplemented animals. Further, George Kunju and Ram (1989) conducting feeding trial on Surti buffaloes observed that in paddy straw consumption increased in block-supplanted group. On farm trial indicated that there was an appreciable increase in feed consumption, increase in milk fat and above all the block supplementation proved economical at village level nutrient supplementation to the buffaloes. On an average the buffalo consumed 350-370 gm block (composition, Table 1.) daily. 3 kg block lasted for week's period. In their earlier formulations they incorporated mineral mixture and cottonseed meal, which were replaced by guar meal and phosphoric acid. In their later formulations, they used fertilizer grade di-ammonium phosphate and magnesium oxide. It reduced the cost and improved quality and texture, as well as the palatability of the block (NDDB, 1996-97). Malik *et al* (1996) have studied the effect of feeding block as such or after soaking in water. They found that 400 gm daily block feeding, after soaking in water and than mixing with the wheat straw increased IVDMD of the wheat straw in rumen of the buffalo. The gas production was also high, and opined that UMMB should be fed as *sani.* Bilala and Murdia (1996), studied effect of block supplementation in Holestein-Friesian heifers. They recorded that inclusion of UMMB to 500 gm daily with concentrate feed supplementation increased digestibility of almost all dietary nutrients and resulted into higher body weight gain (62.5 vs 240 gm/day). DLG was further increased (292 gm/animal/day) when these animals, in addition to concentrate + block supplementation, offered fishmeal.

Multi-nutrient feed block

All above formulations used one or other inorganic material as a binder and blocks dried by chemical processes. The gelling of the block was due to the chemical reaction between the soluble salts of calcium and/or magnesium and phosphorus. Some formulations used calcium oxide as gelling agents. In all cases heat is generated, which may cause nutrient losses. The sticking of the feed ingredient during gelling process is the problem of using active inorganic binder. Bentonite, used as binder, in some of the formulation is non-selective binder of the macro- and micro-minerals, depress availability of the minerals in the animal gut. Considering all these points, simple and appropriate formulations (Table 2) and process technology for production of multi-nutrient feed block, using organic binder (Bohra, 2004) and locally available feed ingredients was developed. Till date 1+12 formulations of compact feed blocks have been developed (Table 3). The standard formulation feed block comprised of wheat bran, sugar cane molasses, urea, vitaminized mineral mixture, dolomite, common salt, deoiled soya bean meal, and guar gum dust used as a binder. (Table 4 & 5). It was observed that partial or complete replacement of wheat bran in block formulations with other fibrous feed ingredients like pearl barley milling products, malt sprouts, deoiled rice barn, *Bajra* husk and *Ardu* leaves though reduced production cost of the blocks, but it lead to low density blocks (Table 3). Pressing of such fibrous ingredient containing mixture required more energy and its upper pressed layer, instead of flat, is of convex shape. Due to low density of such blocks, these are liable to be over consumed by the animals; however, their bulk density can be improved by increasing the level of the binding material. Further evaluation of new feed block formulated indicated that the partial or complete replacement of wheat bran with other fibrous materials reduced the bulk density and subsequently elevated compressive strength of the blocks, however, this rule does not hold true in case of the blocks in which the wheat bran has been fully replaced by chaffed *Cenchrus ciliaris* grass.

The UROMOL (A) produced by the NDDB and MNB (B) produced at CAZRI was compared. The type B block weighed 1.87 kg and NDDB-formulated block produced at RCDF cattle feed plant Jodhpur, weighed 3.02 kg. As such basis, A and B blocks contained 80.4 and 90.0% dry matter, 1.43 and 1.16 gm/cm^3 bulk density, 1.15 and 1.05 gm/cm^3 dry weight density, 15.8 and 100 kg/cm^2 compressive strength, 7.0 and 6.8 pH and 5.19 and 6.37 gm per cent soluble salts, respectively. The compressive strength of CAZRI's block was 6.3 times of the NDDB's uromol block, indicated the superiority of MNB over the UROMOL (Bohra et al, 1999).

Calcium oxide is being used as binder and gelling agents in several formulations. Experiment conducted to record the effect of incorporated of CaO in standard feed block (ST) formulation @ 25, 50, 75, 100 and 150 gm per block, and pressed blocks dried in the solar dryer. On dry matter basis these blocks contained, 1.2, 2.4, 3.6, 4.7 and 7.0% CaO. The dry weight of St, and 1-5 blocks was 2110, and 2055, 2090, 2100, 2130 and 2160 gm, volume, 1817 and 1956, 1925, 1829, 2011 and 2227 cm^3, and bulk density was 1.17 and 1.07, 1.10, 1.18, 1.08 and 1.00 gm/cm^3 , respectively. The data indicated that the bulk density of block contained 75 gm (3.6%) CaO was highest and it was comparable with the standard feed block. The data further indicated that amongst al the formulations tried, the rate of drying was also fast (R^2 = 0.9425) in which 3.6 % CaO was incorporated. Calcium oxide incorporation improved the texture of the blocks. In another trial, magnesium oxide was added @ of 0, 4.1, 9.6, 17.5 and 22.75 of total weight of the block. The fresh weight of these blocks were 2.30, 2.45, 2.60, 2.85 and 3.30 kg, and dry weight were 2.00, 2.20, 2.37, 2.60 and 3.1 kg, respectively. Their bulk density was 1.08, 1.22, 1.37, 1.41 and 1.47 gm/cm^3, respectively. With increasing the level of MgO, the texture of the blocks improved and colour changed from dark to light gray, the bulk density increased and bulk density decreased.

Experiment conducted to asses possibility to assess effect replacement of molasses, wheat bran and guar meal/deoiled soybean (A) meal in standard formulation by various maize starch industry by-products, viz, maize-extractives, maize-gluten-feed and –meal (B). The A and B blocks weighed 1.89 and 1.80 kg, had 2085 and 1939 cu cm volume and 0.91 and 0.93 gm/cu cm bulk density, respectively. The quality of blocks made of Maize Starch Industry by-products was comparable with the standard blocks, contained molasses and wheat bran but former was lighter in colour.

Feeding trial shown higher acceptability of feed block and augmented dry feed and water intake in sheep. The sheep daily consumed 171 gm NDDB's UROMOL and (A), whereas, 342 gm CAZRI"s MNB (B), consumed 740 and 688 gm wheat bran/day, and drank, 2.8 and 3.2 lit water daily, A and B block supplemented sheep. MNB supplemented sheep recorded gain in their live weights, whereas, those on UMB shown reduction. Wheat straw intake in Marwari sheep was appreciably high (535 gm/day & 2.0 kg/100 kg b.wt) in block supplemented than the animal maintained on wheat straw alone (436 gm/day & 1.86 kg/100 kg b.wt). The total dry matter intake including block in former group of animals was 2.6-kg/100 kg b.wt./day. The block supplemented animal daily drank 2.7 lit (10.1 lit/100 kg b.wt), whereas, wheat straw alone fed animals drank 2.3 lit (9.8 lit/100 kg b.wt). During 4 months feeding trial the block-supplemented group recorded 3.6% gain in the live weight; the live weight in wheat straw alone fed sheep was reduced by

8.6%. The average clean wool yield in block-supplemented group was 635 gm, whereas, wheat straw fed seep recorded only 593 gm wool yield (Bohra *et al*, 2001).

Rathi heifers, which had free access to the feed block, consumed daily 678 gm block. In another feeding trial, Rathi heifers first offered 300gm block (B) daily, which was slowly increased to 500 gm/day, and finally to 700 gm/animal/day. Another group was offered wheat straw alone (WS). The WS and B+WS group of animals consumed daily 2.93 kg and 3.01 kg wheat straw and drank, daily 10.8 and 14.0-lit water, respectively. The average daily dry matter intake, including block in the B+WS group was 3.7 kg/animal/day. The daily dry matter intake, per 100 kg body weight in WS and B+WS group were 1.56 and 2.05 kg, and water intake, 5.6 and 7.8 lit/100 kg b.wt.,/day, respectively, however, the feed (kg): water (lit) ratio in these animals were not differed significantly; it was 1; 3.7 and 1: 3.8 in WS and B+WS animals, respectively, and the digestibility coefficient for the DM in these animals was 44.3 and 48.3%, respectively.

A group of Rathi cows, of an average live weight 313 kg, maintained on *Lasiurus sindicus* pasture and offered daily 1.5 kg RCDF pelleted feed, when had free access to the block, on an average, daily licked 332 gm block. During 5 weeks feeding, the block supplemented group gained 3.5%, whereas, non-supplemental but maintained on grazing and concentrates, recorded 1.9% gain over their initial live weight.

A digestibility trial was conducted to evaluate the effect of feed block supplementation in Rathi cattle. 1 group of cattle had free access to wheat straw and water (WS), whereas, another group in addition to these offered 700 gm block/animal/day (B+WS). The feed block on dry matter basis, contained 81.7% organic matter, 18.3% total ash, 26.9% crude protein, 0.4% ether extractives, 54.4% total carbohydrates, 15.6% cell wall constituents and 5.1% acid detergent fibre. These values for the wheat straw were 90.0%, 9.1%, 3.1%, 0.4%, 54.4%, 15.6% and 5.1%, respectively. The daily dry matter, crude protein and water intake in WS and B+WS group were 2.93 and 3.96 kg, 97 and 274 gm and, 11 and 14 lit/animal/day, respectively. The digestibility coefficients for dry matter, organic matter, total carbohydrates, crude protein, ether extractives, NDF and ADF in animals of WS and B+WS were, 44.3 and 48.3; 52.3 and 53.1; 54.4 and 54.0; <0.0 and 43.9; 49.7 and 42.0; 46.5 and 45.8; and 37.5 and 36.7 percent, respectively. The digestibility coefficient for crude protein and DCP value of the wheat straw were <0.0, whereas, of the feed block were 26.85 and 22.4%, respectively (Mondal and Bohra, 2001).

A proto-type solar dryer, can accommodate 4, 2-kg standard blocks, made of ply wood with outer lining of an aluminum sheet, and inside coated with the black paint were designed and its efficacy to dry the blocks were tried. The maximum temperature of its inner chamber during winter and summer was 65°C and 75°C, respectively.

The drying efficacy of electric and solar dryer was compared. The temperature of non-draft type electric oven varied between 65°C -70°C. It can accommodate 12 blocks and the proto-type solar dryer can accommodate 4 blocks. Its diurnal temperature varies between 26°C-78°C. Under both the conditions, it took 4 days to dry the blocks completely. The electric consumption in drying 12 blocks was 8 units (1.35 Rs/block). In case prototype solar dryer, the cost of installation comes to about Rs. 1000/-, there was no any recurring expenditure. The blocks dried in both the dryers were not differed in quality or texture, but those dried in the electric dryer were dark gray and the solar-dried were giving reddish tinge.

As per the farmers' views the feed blocks formulated and produced at CAZRI were well accepted by the livestock. Feed block supplementation, increased feed and water intake. It corrected the craving of animals for unwanted materials (including geophagia) caused by the pica. Farmers' noticed that the block feeding corrected rumination, and there was an increase in the daily milk yield by 20-25%. It became discernible from 5-6th-10th day of introduction of the block. 1, 2-kg block, in case of a cattle and buffalo lasted for 7 and 5 days, respectively. The farmers of Kalyanpur village reported that block introduction increased daily milk yield by 1 lit over its initial production of 3.5 to 4.0 lit/day. In case of a buffalo, an increase in 1.5 lit/day had been recorded (Patel *et al*, 2003). The blocks were also distributed to the farmers of Kutchch region, even a few urea-free blocks, prepared for horses were also distributed. Both were well accepted by the animals.

Establishment of feed block production unit at farmers' level was found to be economic preposition (Rohilla *et al*, 2005). The initial cost of establishment of village level production of 20 blocks/day, including cost of feed ingredients required for production of 100 blocks (Rs.1453/-), essential gadgets and drying oven, comes to Rs. 40,000/-. It excluded the cost of land and infrastructures. The production can be initiated in ventilated, asbestos shade of approx 70'x20', in which 2, 15'x20' spaces, situated at each end of the shade, can be used for storing the ingredients and finished blocks, and a central space of appox., 40'x20', provided with three phase electric connection for ingredient mixer, block press and draught type electric oven can work as production space. The cost of production of 100 blocks using feed grade jaggery (J) and sugar cane molasses (SCM) comes to Rs. 1460/- and Rs. 1310/-, respectively. Assuming a person can daily produce 20 blocks and if working days in the year are considered to be 300 days, the annual profit on production of (20x30=600 blocks comes to Rs. 32,400 (Rs. 2700/-) and Rs. 41,400/- (Rs. 3450/- per month) if J and SCM, respectively, are used for block production.

Nutrient-mixture

The feed block though well accepted and have immense use in supplementation of essential nutrients to the livestock of all the categories, but browsers like goats due to nibbling habit did not lick such block but try to bite it. For such type of animals formulation and technology for production of nutrient mixture have been standardized. It involves mixing of all desired ingredients (Table 2), and then spread over polythene sheet in the sun for drying. Feeding trial conducted on Marwari goat kids and does proved its worth in maintaining their health and productivity (Rohilla *et al*, 2003; Rohilla *et al*, 2004) in these animals. Marwari ewes supplemented with nutrient mixture produced more milk, per day/animal and recorded prolonged lactation period. Daily weight gain in lambs of nutrient-mixture supplemented ewes were also aoppreciably higher that the lambs of control ewes. (Rohilla *et al*, 2004; 2005). Extensive study was conducted on multiparous lactating parbatsar goats, maintained by landless goat owners of *Raika* community of village Bassi in Nagaür district. All the animals were let out for grazing and browsing, to meet out their nutritional requirement on village common grazing land and agriculture fallow. The treatment group of animals was offered daily 100 gm of nutrient mixture after grazing for the period of 60 days. The peak yield of Parbatsar goats, which attined during 90 to 120 days, extended further for next 50 days in treatment group and total lactation yield was also significantly increased in treatment group by 38 lit. The cost of 60 days supplementation feeding of nutrient mixture was estimated to be Rs. 48/- and by sale of additional milk produced by treatment group of animals, the farmer earned rs. 342/-. Nutrient mixture has been found economical as returns were to the tune of about 6 times the cost of the nutrient-mixture (Patel and Bohra (2006).

Mineral-block

Formulation and process for production of mineral blocks was standardized. In formulations 1, 2, 3, and 5, common salt and vitamin-mineral mixture were add in 2:1 ratio, and in formulation No. 4, this ratio was 3:1. In formulation 1 maize flour and guar gum were added @ 24.7 and 1.2%, respectively, and molasses added to facilitate the binding of the ingredients. In No.2 neither molasses nor gum was added but in No.3 gum was added @ 1.6%. In both 3 and 4, 300 ml water was added to facilitate mixing of salt and mineral mixture. In No. 3 and 4, binder was added @ 0.8% level. A 50% *jaggery* solution was also incorporated in No. 3 and 4. In No.5 dolomite was also incorporated. In No. 4 guar gum was added in the last, whereas, in No. 5 it was added before adding dolomite, gum and *jaggery* solution. The fresh and dry weight of No. 1, 2, 3, 4 and 5 formulation blocks were 2.66 and 2.38, 1.77 and 1.63, 1.78 and 1.47, 2.54 and 2.40, and 2.54 and 2.40 kg, respectively. The bulk density of these mineralized salt licks were 1.5, 1.8, 1.3, 1.5 and 1.9 gm/cm^{3,} respectively. No.2 and 3 were brittle, and No. 4 and 5 due to jaggery were soft and sticky in nature. The block made as per formulation No. 1 was appropriate than rest of the formulations (Bohra, 1999).

The technologies developed for production of feed-blocks, nutrient-mixture and salt lick, in present context, have immense potential to augment livestock productivity in drought prone areas and can provide employment in the rural sector of our country. The supplement feed block, nutrient mixture and mineral block production technology provides immense scope to augment utilization of traditional and non-conventional feed resources by the livestock. The CAZRI's supplement-feed and its production technologies have been evaluated under Institute village linkage project and National Agricultural

Technology Projects. Farmers and unemployed graduates have adopted the technology for commercial production of feed-blocks and nutrient-mixture.

Table 1. Percent ingredients and proximate composition of NDDB's and IVRI Urea molasses block

Ingredient	Percent	Percent	Composition	Percent
Molasses	45	45	Moisture	3.0
Urea	15	15	Crude Protein	48.0
Mineral mixture	15	8	Ether extract	0.5
Salt	8	5	Crude fibre	1.5
Calcite powder	4	12	Total ash	34.0
Sodium bentonite	3	3	Silica	2.5
Cotton seed meal	10	12	Calcium	8.0
Sodium bentonite	3	-	Phosphorus	1.2
Source	Malik *et al* (1996)	George Kunju and Ram (1986)		

Table 2. Composition and cost of production of CAZRI's Multi-nutrient Feed Block and Nutrient mixture

S. No.	Feed Block				Nutrient-mixture			
	Ingredient	Quantity, kg	Rate, Rs/kg	Total Cost, Rs	Ingredient	Quantity, kg	Rate, Rs/kg	Total Cost, Rs
1.	Molasses (44.0)	5.2	7.5	39.0	Molasses (46.8)	5.2	7.5	39.0
2.	Urea (4.2%) Water (2.1%)	0.5+0.25 lit water	4.8	2.4	Urea (0.9%) Water (0.45%)	0.1+0.05 lit water	4.8	0.48
3.	Common salt (4.2%)	0.5	1.25	0.63	Common salt (4.5%)	0.5	1.25	0.63
4.	Mineral mixture (4.2%)	0.5**	39.5	19.75	Mineral Mixture (4.5%)	0.5	39.5	19.75
5.	Calcite/Dolomite (4.2%)	0.5	0.80	0.40	Calcite/ Dolomite(4.5%)	0.5	0.80	0.40
6.	Wheat Bran (31.7%)	3.75	5.50	20.63	Wheat Bran (31.7%)	3.75	5.50	20.63
7.	*Guar* meal (4.2%)	0.5	7.75	3.89	*Guar* meal (4.5%)	0.5	7.75	3.89
8.	Guar gum dust (1.02%)	0.12	10.0	1.2				
8.	Wrapper	5	0.80	4.0				
9.	Total for 5-block	11.82/5= 2.364		87.9	Total	11.1 (9.0 kg,dry wt)		84.78
10.	Cost per 2-kg block	2.350 (fresh wt)		17.58	Cost (Rs) per 1- &, 2-kg mixture			9.42 & 18.84

Table 3. Dry matter (gm/gm fresh wt) and bulk density of various multi-nutrient feed block formulations

S. No.	Major Constituents		DM, gm/gm fresh wt	Bulk density, gm/Cu cm	Grading as per bulk density
	Energy sources	Roughages			
Standard	Sugar cane molasses (SCM)	Wheat bran (WB)	0.88	1.25±0.019	B
1	Sugar beet molasses (SBM)	WB	0.84	0.95±0.019	D
2	SBM	WB+Cotton seeds, crushed (5:1)	0.83	0.87±0.022	E
3	Feed grade jaggery (J), 72.2% aqueous	WB	0.79	1.14±0.010	C

	solution				
4	J,73.5% aqueous solution	WB	0.78	1.27±0.018	A
5	SCM	Pearl barley, Industry by-product (BB)+Guar gum dust (GD), 1.5%	0.86	0.98±0.014	C
6	SCM	BB+GD, 2.5%	0.89	1.15±0.016	C
7	SCM	WB+BB (1:1.1)	0.85	1.01±0.010	C
8	SCM	Malt sprouts	0.85	0.88±0.057	E
9	SCM	Rice polishings (RP)+BB (3.7:1)	0.76	1.23±0.012	B
10	SCM	Rice polishings (RP)+BB (1:1.25)	0.82	1.21±0.019	B
11	SCM	*Ardu* leaves+WB+BB (1:1.8:1.6)	0.78	0.93±0.010	D
12	SCM	*Bajra* husk+RP+ Soyabean meal sol extracted (1:1:0.5)	0.81	0.86±0.024	E
	Mean		0.83±0.011	1.06±0.042	

Table 4. Feed Block Production Process Technology (Step by Step)

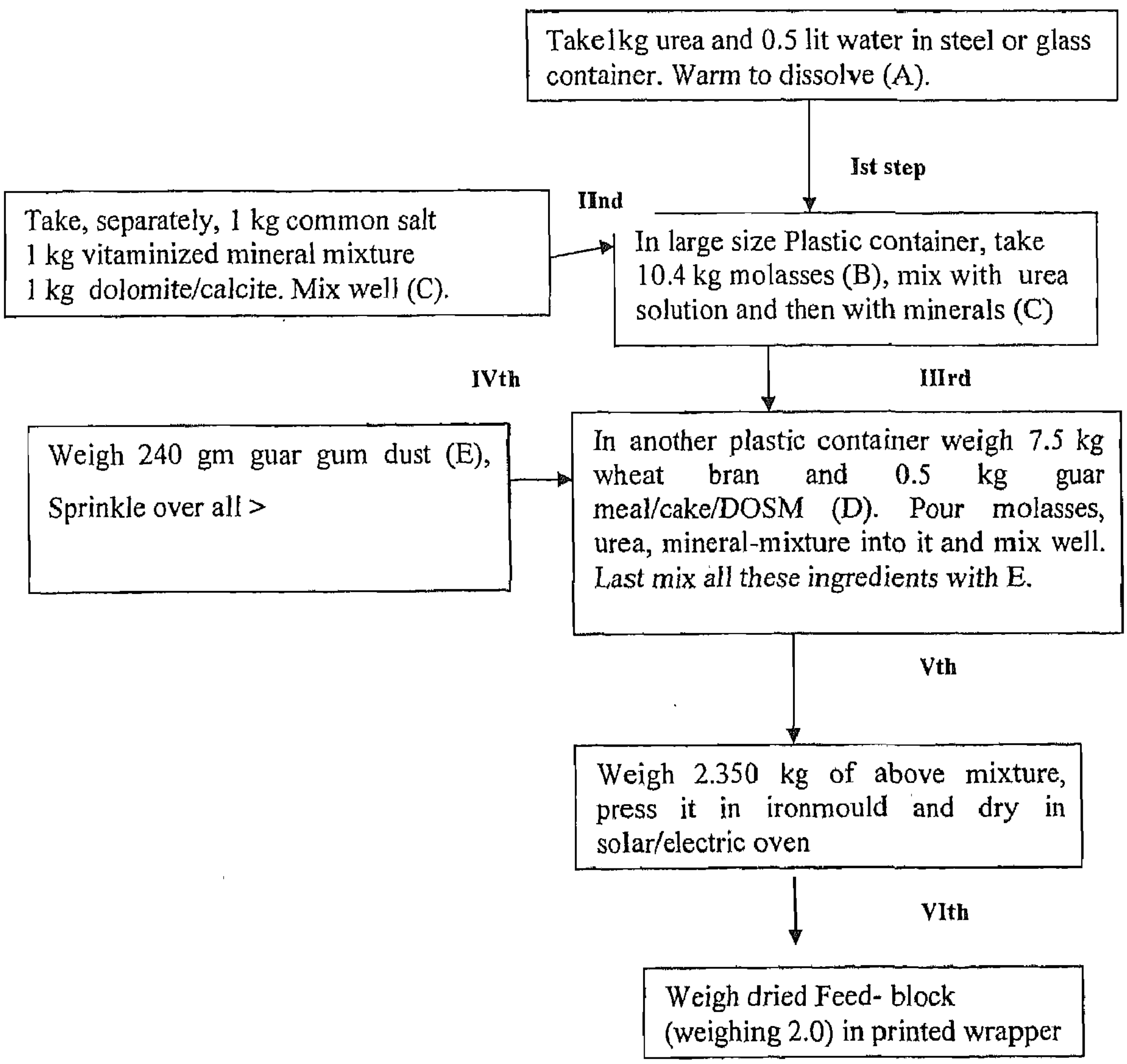

Table 5. Principal and Alternative Ingredients of Multi-nutrient Feed Block and Nutrient-mixture

S. No.	Principal constituent	Alternate constituent (s)
1.	Sugar cane molasses	Sugar beet molasses/ cattle feed grade *jaggery/* maize strip liquor (maize starch industry by-product)
2.	Urea	-
3.	Common salt	-
4.	Dolomite	Calcite/low silica-dried marble slurry
5.	Mineral mixture containing, amino acids and vitamins (A,D,E)	Mineral mixture containing vitamin A/Mineral mixture containing calcium and phosphorus
6.	Wheat bran	Rice polishings and/or deoiled rice bran, Pearl barley by-products/Malt sprouts/Dried Neem or Ardu leaves, seed free powdered Prosopis juliflora or Acacia tortilis pods/ ground dhaman grass, bajra grain husk and rice polishing mixture/maize gluten feed
7.	De-oiled soyabean meal	Guar meal: korma or churi/any cake of oil bearing seed/ Cotton seed whole, ground
8.	Organic binder (guar gum dust)	1. Organic: Fenugric seeds, ground 2. Inorganic: Cement, Magnesium oxide, Bentonite or sodium bentonate/ Gypsum/Calcium oxide

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FEED PROCESSING AS COMPLETE FEED BLOCK FOR SUSTAINABLE ANIMAL PRODUCTION IN ARID AND SEMI ARID REGIONS

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The arid region of India covers about 12 % of the world's hot arid area of which Rajasthan contributes 61 %, Haryana and Punjab 9 % and Andhra Pradesh and Karnataka 10 %. The Indian arid zone by far is the most populated arid area in the world and even till date despite extreme degradation, the major stay of rural economy is grazing based livestock production system because the uncertainty of rain fall in association with other characteristics of arid region makes crop husbandry to be hostile to agriculture production.

The arid and semi arid lands experiences stress due to climatic variability and increasing requirements of livestock and human population. Over exploitation of natural resources by increasing biotic pressure is though throughout the country on more than 40 % of the total geographical area available for grazing by over 500 million livestock but in arid and semi arid regions occupying major share, the situation is more desperate. In these regions, the population pressure gets further compounded by drought causing extreme pressure on vegetation through overstocking. The existing grazing pressure in arid area is very high i. e. 1 to 4 ACU/ha. against the normal 0.2 to 0.54 ACU/ha. (Beniwal and Singh, 2005). Further, the frequent drought often leads to complete crop failure. A good crop year has been observed to have a cyclic nature of 11 years (Sharma and Garg, 2005).

Under such situation of aforesaid detailed adversities, livestock farming has been noticed to come forward to alleviate the effects of drought and fodder scarcity and that is why it has become a major component of arid agriculture. The animal husbandry based farming system not only enhances economic viability of farming systems but also increases the sustainability of farming system, more appropriately in rain fed arid ecosystem (Gahlot *et al.*,2005). Probably due to this reason the arid region of the country is better ranked than the rest of the regions in terms of production of milk (>18 %), meat (>20 %) in terms of live animals and fibres (>25 %) (Sharma and Garg, 2005). In addition to the provisions of quality nutrition and industrial raw material (wool, leather etc.), the contribution of livestock in terms of manure and draught power cannot be under estimated. Over and above this, the added advantages of this sector in arid socio-economic set up are stability, round the year employment opportunity, equity distribution and being technologically simple. (Anonymous, 2006).

The role of animal husbandry sector in arid agricultural is expected to increase manifold provided inputs in terms of feed and care, an animal receive during its life time are adequately provided.
Natural calamities those directly affects the feed resource availability are drought, flood, earth quake, cyclone, landslide, hailstorm etc., besides, political disturbances such as war, bandh, restrict movement of feed resources and also the availability (Thole *et al.*, 1991). In such situation primary aim should be the saving of the life of productive and growing stock by providing minimum nutritional inputs. In arid and semi arid area suffering from acute shortage of feed and fodder, the drought or famine is the natural calamity becoming almost regular feature and is considered by many to be the most complex but least understood of all natural hazards, affecting more people than any other. Though drought is normal feature and its recurrence is inevitable yet, there remains much confusion with in scientific and policy community about its characteristics. It is precisely this confusion that explains to some extent the lack of progress in drought management in most part of the world (White, 2000).

In arid area, the persistent drought which often leads to complete crop failure and consequently complete crop residue failure in association with extreme degradation of erst while pastures and drastic reduction of common property resources, exposes livestock to a situation where even very poor quality feed resources (in no way expected to meet minimum nutritional requirement of animals) are not available adequately. The situation is particularly more grave with marginal and small farmers have little or no capacity to produce and store animal feeds and that is why during drought they are the first to be affected. Invariably the sheep and goat are disposed for slaughter during such periods, giving at least some monetary benefits but the large ruminants turns out to be a liability non meetable by the farmers, requires immediate intervention by the government and non government agencies. Further it has also been observed that even after the adequate intervention by these agencies the existing genotype or breed suffers great loss in affected pockets. Though during the next good rainfall year, farmers again purchase cattle from surrounding states or areas, the cattle may be of some good breed but there is essential dilution of the existing germplasm which is perhaps non compensatable loss.

Keeping the aforesaid facts in view and realizing that the nutritional inadequacy in the arid and semi arid area for livestock under existing circumstances will be a persistent feature, the efforts are required to be proactive rather than reactive to coup with. To make people living in these areas more self reliant by improving economic viability and sustainability of livestock sector in rain fed arid and semi arid areas, a dependable feeding strategy in terms of fodder banking is required to be formulated for improving nutrient availability.

Need of the new technology

National Waste Land Development Board (1991), through a survey recorded that out of 55 micro regions only 12 regions have showed surplus whereas, 43 regions across the country suffer from scarcity of fodder for livestock. Punjab, Haryana and Western Utter Pradesh are the regions facing problems regarding disposal of cereal crop residues and contrary to this the livestock of Rajasthan, Gujarat, West Bengal, Andhra Pradesh and Orissa are striving for these crop residues.

Looking to the present time availability of feed and fodder resources as well as livestock availability in arid and semiarid area, the self sufficiency seems to be far away and dependence upon the import of fodder from surplus area will be there to meet the requirements at least during exigencies. However, it can also be very well appreciated from experience of past where during emergencies of natural calamities shifting of crop residues from surplus and growing areas has been one of the first crisis management steps taken up by the government agencies. But at the same time it is also important to understand that due to low bulk density of fodder long distance transportation is a non viable proposition. In the financial year 2002-03 alone 7406.20 lakh of rupees were spent by the state government of Rajasthan for the transportation of basal roughages like cereal and pulses crop residues, grasses etc. from surplus and growing areas. It has been estimated that the cost of tariff beyond 200 km is equivalent to actual price of roughage (Samanta *et al.*, 2004). Therefore, need of technology that could facilitate safe and economic transportation by enhancing the bulk density of basal roughage sources is there and it has been observed by many workers that densification as such may play a major role in this regard. Enhancement in bulk density of important feeds by compaction can be appreciated from the table 1.

Table 1. Bulk density of raw feeds and blocks

S. No.	Feed	Bulk Density of Feed (kg/m^3)	Bulk Density of Feed block (kg/m^3)
1.	Ground nut straw	81.00	553.63
2.	Ardu leaves	51.50	539.06
3.	Mustard straw	51.48	562.21
4.	Gram straw	66.48	471.94
5.	Wheat straw	57.22	347.22
6.	Jowar straw	70.00	437.20

7.	Paddy straw	70.00	279.00
8.	Forest grass	66.33	503.00
9.	Bajra karbi	119.60	511.10
10.	Cenchrus grass	67.50	486.84
11.	Arhar straw	55.00	689.06
12.	Sugarcane bagasse	61.0	567.50
13.	Cluster bean	109.00	596.67
14.	Wheat straw (with molasses 5 %)	70.00	570.67
15.	Mango leaves	17.00	643.20
16.	Sugarcane top (with mustard cake 10 % + molasses 10 %)	105.00	352.00

Source: Report NATP Project "Evaluation of Locally available---------diets" (2001-02)

Mechanical densification of fodder in fact is a value adding process. It leads to advantages like reduction in transportation cost, storage space and better safety during transportation (Singh *et al.*, 2004). The available options of densification are bailing, pelleting and briquetting. In Gujarat, Maharashtra and Rajasthan sporadically locally designed vertical bailers are used to prepare the grass bales of 114x114x86 cm^3 size of 115 kg weight. The main draw back of this machine is the low bulk density (Samanta *et al.*, 2004). In case of pelleting though the densification is very high but it is energy intensive due to chopping, grinding requirements of fodder. The third option is briqueting technology by use of pressure and heat, though it densify fodder 10-12 times but it has been observed that none of these technologies can handle efficiently the feed material having large particles and higher proportion of crop residues.

Why complete feed block

Simply by making provision of adequate roughage to meet the exigencies by shifting cereal straw roughages from surplus or growing areas is not enough to overcome the scarcity of fodder in general and impact of drought in specific. In fact we are required to ensure adequate balanced nutrition to the animals to maintain body weight above critical levels including allowance for growing stock or pregnant and lactating animals. Thus, combining of densification with concept of complete feed is a viable proposition for developing fodder banks to arrive at sustainable livestock production in the arid and semi arid areas. A complete feed machine devised by the Indian Agricultural Research Institute (IARI) seems to be appropriate to meet these objective of provision of complete feed provided to the animal in densified form (Singh *et al.*, 2002).

It is not only that complete feed blocks can be transported over any distance conveniently without any loss to provide adequate balanced feed to the animals at the time of scarcity but the processing involved in formation of blocks is also reported to considerably improve the feed consumption, growth rate and efficiency of feed utilization both from concentrate and roughages (Sharma and Garg, 2005; Anonymous, 2005; Kumar *et al.*, 2004; Nagpal and Jabbar, 2005).

Complete feed technology

The "Complete Feed Block" is a densified product compressed at different pressures depending upon species, containing both roughage and concentrate in desired proportion to fulfill the nutrient requirements of target animal production (Samanta *et al.*, 2003). The block may be square, quadrangle or circular depending upon the dye used in the pressure applying machine.

Advantages of complete feed blocks

1. Non-conventional, less palatable feeds can be used which help in reducing the total cost of feed.
2. During storage, prepared feed blocks required one third less space as compared to their loose form
3. Transportation of such blocks is convenient and trouble free.

4. Reduces transportation and storage cost.
5. The palatability, voluntary intake and nutrient utilization of low-grade roughages are increased.
6. In the form of blocks the fermentation of feed is better in the rumen of animal because concentrate stick to roughage on application of high pressure during block formation resulting into stable rumen environment.
7. Prevents loss of lighter nutrients resulted from sneezing.
8. Reduces the wastage of feed material by animal during feeding.
9. Saves labour on feeding management.

Complete feed block making machine

(A) Structural and operational details of the machine

Complete feed block making machine can compress all kinds of feed material to square shape (20 cmx20 cm) and of desired thickness and weight. The working pressure of the machine can be raised up to 6000 PSI, the output capacity of the machine is 30-40 blocks / hour. The bulk density of the roughage based feed blocks prepared from this machine has been found to be 4 to 5 times more than the original feed. It would increase even more if fixed with binders and concentrates, the machine is powered with 15 H. P. electric motor and it consists of following components.

1. Frame 2. Power pack
3. Hydraulic Cylinder 4. Electric control panel

(B) Advantages of Machine

This machine is very simple in operation and only one person (skilled/unskilled) is required to regulate entire operation of the machine. The working pressure of machine is adjustable (up to 6000 PSI). It can compact all kinds of feed materials to square shape (20 X 20 cm.) and of desired thickness and weight. The blocks retain their shape at compaction for long duration. Guar straw, mustard straw and sugarcane bagasse can form stable blocks when densified at a natural dried moisture content and 418.5 kg/cm^2 pressure. The increase in the moisture content of the materials caused very high resiliency, hence, instability of the compacted blocks.

(C) Cost of operation of animal feed block making machine

The cost components in feed block formation with the animal feed block making machine can be divided into fixed cost (depreciation, interest on investment, taxes, insurance) and operational cost (repair and maintenance, lubrication, electrical charges, wages of unskilled labour).

Major components for operational costs are given in table 2 based on these the cost of complete feed blocks comes to Rs. 375/MT.

Table 2. Cost component for operation of complete feed block making machine

1.	Price of the machine	Rs. 425000
2.	Capacity of the machine	2 MT per day
3.	Life of the machine	20 years
4.	Interest rate	15 %
5.	Working days per year	300
6.	Working hours per day	10
7.	Salvage value	5 %
8.	Weight of the machine	3.5 ton
9.	Overall size of the machine	17 ft X 6 ft X 8 ft
10.	Power requirement	15 HP, 3 Phase
11.	Labour requirement	1

Source: Report NATP Project "Evaluation of Locally available---------diets" (2001-02)

(D) Break even analysis

The break even analysis shows the profits from the excess of the total revenues over total cost. The break even point identifies the volume of the activity at which total revenues equals total cost. This is often an important point for decision making because it represents a minimum acceptable level of operations. The break even point is defined as the level of operation at which total revenues (TR) equals total cost (TC). It is that volume of output where fixed cost (FC) and variable costs (VC) are covered but no profit exists. The relationship between cost and revenues for different volumes of output indicates that break even point for this machine is 105 tones. This means that the machine will give profits when the volume of production exceeds this figure.

Effect of pressure on bulk density

The study of effect of different pressures viz. 2000, 3000 and 4000 PSI on bulk density considering physical characteristics of blocks prepared for different roughages like grasses, straws, stovers, tree leaves etc. in combination with formulated concentrate mixture (60: 40) showed that with decreasing pressure the expansion of compressed feed material increased with passage of time and consequently bulk density decreased. Bulk density of grass and concentrate mixture (60: 40) increased by 8.41, 7.65 and 7.31 fold at 4000,3000 and 2000 PSI, respectively as compared to loose form. Pressure application appears to be the most critical factor in making of complete feed block (Kundu *et al.*, 1998). Further studies (Samanta *et al.*, 2004) have also shown that blocks prepared from straws like wheat and paddy may get broken even while dropping from 1 meter height, therefore, require a suitable binder for making blocks for complete feeds having such roughages in composition.

Scope of incorporation of unpalatable feed and fodder

In spite of high nutritive value some of the feeds are unpalatable due to presence of some phyto toxins that restricts its use in livestock feeding. But by incorporating such feeds in complete feed blend these can be efficiently utilized in livestock feeding as it prevents selective eating by animals. Certain non conventional feeds such as cotton straw, mustard straw, gram straw, tumba seed cake, mesquite pods, mahua cake etc. have been successfully incorporated in the complete feed blocks at different levels (Samanta, 2004; Anonymous, 2005). Thus, the non-conventional roughages and concentrate having low palatability can be judiciously incorporated in complete feed blocks for sustainable animal production.

Reduction in transportation cost

The very wide inequality among areas regarding availability of roughages throughout the country in general and during natural calamities in specific require little or more transportation of straws, stovers and grasses from the area of surplus to the affected pockets but as such the transportation of roughages has always been observed to be non viable proposition due to their low bulk density, commonly ranging between 65-75 kg/m^3 (Yadav, 1990). The densification through complete feed block machine enhances bulk density by 5-8 times for roughages alone and 4-6 times for complete feeds containing roughages and concentrate in the ration at 60:40 ratio (Samanta, 2004).

Table 3 shows the effect of densification on reduction in the transportation cost for various distances for grass and straws transported in loose and block form. The reduction in transportation cost could be revealed to the extent of 94 % as compared to loose form as a result of enhancement in bulk density. In case of straws the reduction in cost could be observed to the extent of 77 % while carrying the material to a distance of 100-400km. Thus, from these observations it appears that densification is suitable answer for transportation of roughages not only in the state of emergency but in routine also by combining it with the concept of complete feed for proper disposal of roughages at production site and ensuring of adequate balanced nutrition to the animals of scarcity prone area.

Table 3: Effect of densification on reduction of transportation cost

Feed materials	Block density (kg/m^3)	Capacity (qt/truck)	Transportation cost (rupees / qt.)			Reduction in transportation cost (%)
			100 km	200 km	400 km	
Grass loose	25	7.25	620	896	1379	
Grass block	453	131.37	34	49	76	94
Wheat straw loose	94	27.26	165	238	366	
Wheat straw block	421	122.09	36	53	81	77
Paddy straw loose	89	25.81	174	251	387	
Paddy straw block	395	114.55	39	57	87	77

Source: Samanta (2004)

Reduction of storage space

For developing fodder banking the requirement of space for storage is also a matter of serious concern and as such most of the roughages used in animal feeding require huge space for storage. The reduction in storage space for various roughages as a result of compaction could be well appreciated from the figures shown in table 4.

The increase in bulk density on making complete feed blocks facilitates convenient and economic handling, storage and transportation (Verma, 1996). Therefore, this technology could be applied as viable component of "Famine Feed Bank" in drought prone areas of arid and semi arid parts of the country.

Table 4: Reduction in storage space

Feed resources	*Space required per qt. in loose form* (m^3)	*Space required per qt. in block form* (m^3)	Reduction in space requirement (m^3/qt.)
Grass	3.89	0.22	3.67
Wheat straw	1.06	0.24	0.82
Paddy straw	4.04	0.25	3.79
Black gram straw	1.69	0.18	1.51
Ground nut haulm	1.78	0.17	1.61
Stylo straw	3.54	0.21	3.33
Sorghum stover	2.36	0.18	2.18
L. leucocephala leaves	1.20	0.13	1.07

Source: Samanta (2004)

Acceptability of complete feed block by animals

A variety of locally available straws, grasses and other non conventional feed have been used as major roughage source in complete feed blocks successfully. The values of intake and digestibility recorded in various species for different combinations of complete feed blocks have shown that as such there is no adverse effect on intake and digestibility due to compaction of complete feed and the non conventional low palatability feeds can be efficiently utilized in the feeding of animals for economic animal production. The intake and digestibility of dry matter of some of the combinations of complete feed blocks have been presented in table 5 to reveal the acceptability of complete feed blocks by different species of animals.

Table 5: Intake & digestibility of complete feed blocks

Blocks type	DMI kg/100 kg.	DMD %	Animal species
Mustard straw based	3.23-3.78	48.86	Sheep
Bajra kadbi based	3.38-4.23		Sheep
Mustard straw with tree leaves based	2.50-3.73	42.5	Sheep
Natural grass based	2.58-3.08	48.99	Hybrid calves
Natural grass based	2.90-3.06	60.10	Goat
Mesquite pods based	3.32-3.64	64.58	Sheep
Groundnut hull based	3.514-4.06	58.15	Sheep
Groundnut straw + Wheat straw based	3.99-4.09	62.71	Calves

Source: Report NATP Project "Evaluation of Locally available---------diets" (1999-2005)

Conclusion

Livestock farming is the major component of arid agriculture as it makes arid rural economy more viable and sustainable. The majority of basal roughages and concentrates required for feeding of livestock originate in the areas where crop husbandry has been intensified. This unequal natural distribution require transportation of both roughage and concentrate from production area to the area of consumption. On account of high bulk density concentrate do not pose problem but shifting of roughage is a non viable proposition due to low bulk density. Thus, densification is dire need to minimize cost of transportation of roughages. Further, for sustainable livestock production, the need of adequate balanced nutrition to animals for targeted production arises. The densified block form of complete feed not only overcomes the problems associated with the transportation, handling and storage of feed but also provide adequate balanced nutrition to the animals at the time of scarcity to sustain productivity. Thus, "Complete Feed Blocks" feed processing technology may be foreseen as viable tool that can boost up the economic gains of livestock owners to change the socioeconomic scenario of arid and semi arid area through improved sustainable livestock production.

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COMPLETE FEED & FODDER BLOCKS – A STRATEGIC APPROACH TO COMBAT FEED STRESS SITUATIONS

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Efficient utilization of crop residues and agro industrial by products as animal feed assumed importance due to shortage of dry roughages, concentrates and green roughage to an extent of 45, 44 and 39% respectively. Due to cultivation of commercial crops, huge quantities of different type of crop residues are produced every year as a renewable resource. These crops residues are rich in fibre and low in nitrogen and are not palatable. Any processing method that improves the nutritive value of these crop residues will enhance the density of nutrients per unit of feedstuff and go a long way to bridge the gap between availability and requirement of roughages to existing live-stock population (Anon, 2001-02).

Processing: More than 30 processing methods have been developed experimentally or practically to improve the intake and digestibility of crop residues. These processes include physical, chemical and biological methods. Most of the methods have been technically successful and have been exhaustively investigated.

Physical methods: Physical methods include chaffing, soaking, grinding, block formulation, pelleting, extrusion, steam under pressure and irradiation. Chaffing is a less severe processing method and aimed at preventing selection of highly nutritive tender parts by animals to reduce the particle size and to present feed wastage. Feeding of chaffed or long straw did not affect the digestibility in sheep (Devendra, 1983) but consumption of chaffed straw was higher than long straw (Castillo *et al*, 1982). The bulk density increases markedly by grinding, blocks and pellet making. As reported by Reddy and Reddy (1990), grinding increased the density of cottonseeds hulls by 30% and dried forest grasses by 88%. It was also reported that pelleting of ground material increased the density of maize crops by 54% and that of maize straw by 236%. (Ready and Reddy, 1990). Similarly feed block increases straw density. Grinding does not improve the digestibility of fibre fractions of crop residues but some times reduces their digestibility as compared to chaffing. This might be due to faster rate of passage from reticulo-rumen (Greenhalgh and Wainman, 1972).

In order to utilize crop residues in the rations of ruminants, crop residue have to be subject to at least a minimum processing like chaffing/grinding. Economical and balanced feeding of livestock for optimum production in extremely important. Lower live-stock productively in our country is mainly

Complete feed concept: The term complete feed is used synonymously with the term total mixed ration (TMR) or complete ration (CR). It is a quantitative mixture of all dietary ingredients blended thoroughly to prevent separation and selection and is formulated to meet the specific nutrient requirements. Interest in complete feed is increasing world over because it has balanced ratio of concentrate to roughage and also nutrients consumed and low feeding costs. It ensures better consumption, avoids refusal of unpalatable nutrients, and reduces eating and rumination time and thus increases resting time. A even intake of feed into rumen leads to less fluctuation in release of ammonia and non-protein nitrogen is more efficiently utilized. Waste materials like baggase, cottonseed hulls, Corn silage, alphalpha grass silage, ground hay (Ibrahim & Ingalls 1971), waste paper, berseem hay and poultry dropping were successfully used in complete feed diet (Kesler et al 19670.

Complete feed block: As the name indicates it is a animal edible product made by compacting complete feed containing roughage and concentrate in a designed proportion capable to fulfill the nutrient requirement for the targeted animal production system. The complete process is normally mechanical. The complete feed blocks may be square, rectangular or in any designed shape depending upon the type of dye used in the pressure applying machine.

Methodology for preparation of complete feed Block: Feed resources i.e. roughage, concentrate or any ingredients needs to be incorporated are properly mixed with desired preparation in mixer for through mixing and equal distribution. The mixed material is then put in the hopper of the feed block making machine. Then the presser in applied after closing the hopper for densification. The automatic mode ensures opening of door for release of complete feed block through piston. Then the blocks are already to use either for feeding or for storage or transportation.

The formulae for complete diets contains different ingredients like roughages (crop residues, legume hay, straws, grasses etc). Protein supplements (ground nut cake, mustard or any cake or gram, moong, moth or urd churi), energy supplements (rice bran, wheat bran, maize, bajra, molasses etc.), mineral supplement (mineral mixture, salt etc.) and vitamins supplements. The roughage portion can be partly replaced by legume hay if available. These ingredients are than can be processed into mash, block or pellets to make complete feed.

Role of livestock in national economy: World' current population of cattle, buffaloes, sheep and goats is around 1355.1, 174.0, 1081.1 and 807.6 million respectively. Asian region possesses about 33.61, 96.88, 42.29 and 64.33 % and India 13.65, 56.31, 5.79 and 14.87 % of the total world population of the four respective livestock species (FAO, 2005). India ranked first in cattle, buffalo and goat population in the world. Although the population of all the four livestock species has shown increasing trend since 1951 the buffalo and goat population has increased more rapidly than other species and they are considered the animals of the future for the country (Table1). The livestock sector has experienced significant growth in terms of its contribution to the national economy during the last few decades. The contribution of agriculture and allied sectors to the national Gross Domestic Products (GPD) has declined from 55 % in early 1950s to 23.9 % in 2001-02. But the share of livestock sector to agricultural GPD has increased from 18.1 % in 1980-81 to 25.5 % in 2001-02 (Sharma, 2004). Livestock being a source of livelihood and employment in rural areas is the backbone of Indian agriculture.

Feed and fodder resources: Man, Animal and Nature are symbiotic relationship for their survival and substance. The balance maintained among the three for several millennia has been disturbed by over exploitation of natural resources for meeting the demands of increasing population of men and animals. The gravity of the situation can be gauged from the fact that India, with only 2.29 % of land area of the world, is maintaining nearly 17.4 5% of the world's human population and about 10.71 % of the livestock. The major feed resources in our country are grasses, community grazing, crop residues, cultivated fodders, edible weeds, tree leaves and agro-industrial by-products. Ramachandra et al (2001) and Ranjhan (2003) have reported potential availability and requirements of livestock feeds and fodders in the country. Most of the ruminant population in arid and semi-arid regions of our country are fed mainly on crop residues in addition to grazing of the available rangelands with little or no supplementation with concentrates that include agro-industrial by-products. Crop residues and by-products constitute the main feeds accounting for 40 % of the total consumption of different livestock. Green fodders contribute 26 %, the concentrates 3 % and the rest is coming from grazing (Mathur, 2004). A large gap exists between the requirement and the availability of feed and fodders in the country as a whole. A shortage of about 31 % dry fodder, 23 % of green fodders and 47% of concentrates has been estimated for meeting the requirements of existing livestock population in the country. Recent surveys conducted by the National Institute of Animal Nutrition and Physiology, Bangalore, have revealed 45% shortage of dry roughages, 44% shortage of concentrates and 38% shortage of green fodders in the country (Singh and Ramchandra, 2004). The situation in arid and semi-arid regions is much more serious. The feed scarcity is mostly due to increasing human and livestock population, deterioration of common grazing lands both in quality and quantity, lack of adoption of feed and fodder production and processing technologies and low priorities given for identifying, improving and utilizing the newer feed and fodder resources.

Arable agriculture contributions a major fodder resource in the form of crop residues, which are extensively fed to the livestock. Wheat straw is transported from surplus areas such as Punjab, Haryana and western Uttar Pradesh to deficit areas mostly the Himalayan Hills, Rajasthan and Gujarat. Fodder crops like oats, berseem, Lucerne, maize, jowar, cowpea and bajra are also sown. Cultivation of fodder crops is limited to irrigated areas and land rich farmers. Sale of green and dry fodders through retail outlets is a common practice. The area cultivated for fodder amounts to 4% of the total cultivable area. However, exclusive pastures and grasslands are widespread and are grazed by domestic animals. The total area under permanent pastures and grasslands is about 12.4 M ha or 3.9% of the country's geographical area. An area of 15.6M ha, classified as wasteland is also used for grazing. Forests and their associated grasslands and fodder trees, are another major source of grazing and fodder collection. The estimations made by Patil et al. (2005) *on supply, demand and deficit of green and dry fodders from 1995 to 2025 are included in Table 2.*

Complete feed & fodder blocks to combat feed stress situation: India has 3.81 lakh square km land under arid and 9.56 lakh square km under semi arid conditions (Suresh Kumar, 2005). The arid zone of India covers about 61.0%; Punjab and Haryana 9%; AP and Karnataka constitute 10.0%. The India Arid zone by far the most populated arid area in the world and even till date despite extreme degradation, the major stay of rural economy is grazing based livestock production system (TribhwanSharma, 2005). Arid and semi arid lands experience stress due to climatic variability and increasing requirement of livestock and human population.

Natural calamities, those directly affect, the feed availability are drought, flood earthquake, cyclone, land slide and hail storm etc. Political disturbances such as war, bandh restrict the movement of feed resources and also the availability (Thole et al 1991). In such situation primary aim should be saving of the life of animals by providing minimum nutritional input. In arid area drought or famine is the natural calamity becoming almost regular feature and is considered by many to be the most complex but least understood of all natural hazards (Withite, 2000).

Deficit fodder availability due to scanty rainfall coupled with squeezing and degrading grazing land is major constraints for livestock production in arid and semi arid regions. In normal rainfall years, the productively of forage from grasslands as well as from cultivated areas is high during monsoon months and thus is surplus availability of forage during the period. Leaf fodder from top feed species is also high during this period. However the forage supply becomes an acute shortage during the period of draught. Therefore production cum-conservation strategy is inevitable in maintaining optimum livestock production through out the year and particularly in time of draught. In Rajasthan Stover's of pear millet and moth bean and guar by products constitutes the major source of fodder for livestock. Hay of annual and perennial grasses and other palatable legumes and forbs etc. is conserved traditionally by the inhabitants and fed to animals. So there is need for densification of voluminous dry fodder and hay for easy and economic transport particularly during the period of draught (Beniwal and Singh 2005).

Factors affecting complete feed formulation: The formulation of complete feed blocks is determined and affected by nutrient density, particle size, forage concentrate ratio, source and level of roughage.

Nutrient density: The nutrient density changes depending upon on the type of feed used in the ration. In dry hay or roughage, nutrient density decrease as it tends to bulk up the ration. As the nutrient density decrease, the ration volume per animal increases. With the increase in density of energy in ration of Holstein cows feed intake, milk yield, milk protein and lactose yield showed linear increase (Mac leod et al, 1984).

Particle size: Particle size is an important factor to be considered for processing of complete feed diets to maintain the milk fat level. Diets having smaller forage particle size enter rumen at a smaller size after initial chewing and swallowing and therefore leave the rumen faster, resulting in increased fractional turnover rate of ruminal DM (Martz and Belyea, 986; Fahey and Berger 1988). Smaller forage practices spend less time in the rumen for microbial digestion thereby decreasing digestibility and particularly of fibre digestion. The increased intake and improved nutritive value of low quality crop residues after mechanical processing in mainly due to particle size reduction. The optimum particle size for improved intake and increasing the density of feed is crucial in the processing of complete feed diets. Amount and physical form of fibre are important in diet of lactating dairy cows to maintain normal milk fat and chewing activities. Intake of long roughages particularly straw in conventional feeding resulted in reduced milk fat where as complete diets maintained normal butter fat level in Friesian cows (Owen et al 1969). Milk fat depression (MFD) is due to feeding of ration low in fibre (NDF) either because of restricting forage fibre or lowering forage to concentrate intake in the diet (Wood ford et al 1986). Inclusion of only 20% roughage in complete feed resulted in secretion of milk containing relatively low fat (Emery et al 1964). NRC (1989) recommended a minimum of 25 to 28% dietary NDF of which 75% should be supplied by forage. Insufficient particle size decrease the ruminal acetate to propionate ratio and pH, which in turn lowers milk fat percentage (Grant et al 1990 b and Woodford et al 1986). At luminal pH below 6.0, growth of the celluloytic bacteria is depressed, increasing the microbes that produce more propionate and decrease acetate to propionate ratio (Grant et al 1990a). Reduced forage particle size increases DMI; decrease digestibility and retention time of solids in the rumen (Martz & Belgea 1986, Uden 1987).

Forage concentrate Ration: Complete ration provides adequate and balanced nutrients in an optimum ratio of concentrate and roughage (Krishna et al 1977). Moseley et al (1976) found that abrupt increase in concentrate increases the consumption of DM and energy, yield of milk and FCM, percentage of milk protein and ruminal concentration of propionate and total acids and decreases percentage of milk fat, total solids, ruminal pH, concentration of butyrate and acetate: propionate ratio. Increase in forage proportion in complete ration has the opposite affects.

Source and level of roughage: The level and source of roughage in the complete feed is apparently of major importance. Suitably processed fibres crop residues can be successfully used as a sole source of roughage in complete feeds for optimum growth and milk production (Reddy 1988, Reddy et al 2003). Characteristics and level of roughages in ruminant ration are crucial for maintaining desirable VFA pattern in the rumen and could influence animal performance (Sudweeks 1977). Chewing activity influence the rate and amount of saliva secretion, which in turn is influenced by the source of forage (Weltch & Smith 1970). Dietary NDF is negatively associated with digestibility and DMI and is associated with feed intake depression (Kharusani et al 1993).

Advantages of complete feed and fodder blocks

Nutrients intake and animal performance: In an experiment (Yadav, 1988), the adult buffaloes were fed complete feed blocks made of ungrounded wheat straw (T1), ground wheat straw (T2), ungrounded paddy straw (T30 and ground paddy straw (T4). The DM intake was more in paddy straw based blocks as compared to the wheat straw based blocks. Grinding of straws improved its DM intake. The digestibility coefficients of all the nutrients were higher in paddy straw than the wheat straw based blocks and the coefficients decreased due to grinding of straws. Jaglan (2002) conducted an experiment on crossbred heifers by feeding complete feed blocks made of untreated wheat straw (T1) and it was replaced by urea treated paddy straw (T2), mustard straw (T3) and sugarcane baggasse (T4) at 50.0% level respectively. In each experiment roughage to concentrate ratio was kept 60:40. The DM intake and daily body weight gain were higher while the cost per kg live weight gain was maximum in T1 than the other treatments. Samanta et al (2003) found that there is an increase in dry matter intake in female crossbreed calves (15-18%), buffaloes (20%) and in lactating cows (8%) from block form than its mesh form of diet. The higher dry matter intake on feeding of densified complete diet does not influence the digestibility of various nutrients. Similarly in an experiment (Lailer et al 2006) on buffalo heifers found a significant ($P<0.01$) higher growth rate (613.83 gm/day) in complete feed block fed group as compared to control group (447.50 g/day) in which the same feed ingredients were fed in the conventional way of feeding. The overall increase in dry matter intake was 17.63% in blocks fed group and the increase in dry matter intake from wheat straw was 27.74% in the block fed group.

Enhance bulk density of roughage: The roughage resources are bulky in nature and characterized by low bulk density. Thus, transportation of these materials during emergency (flood, draught, famine, cyclone, earth quake etc) is not cost effective and accounts huge exchequer. Therefore, making of blocks of above resources enhances the bulk density into several times, which in turn facilitates transportation at cheaper rates from surplus region to deficit areas. Table1 shows the natural bulk density and bulk density of compressed common roughages.

Reduction in storage space and transportation cost: Conventionally, roughage materials are stored in heap (field) or in godown, which occupies huge space due to low bulk density. Therefore, storing of roughage for peri-urban dairyman is costly affair as every square inch fetches huge amount in cities. Table2 shows the saving of storage space after making feed blocks.

Keeping quality: Storing of roughages at open area sometimes aired away by storm or heavy winds, which causes loss of precious biomass. Heavier particle may settle in storing space but lighter leafy nutritious part may fly away which reduces the nutritive value of roughages. Similarly the sweeter ingredients of concentrate mixture are eaten by the rat, cockroach etc. this adversely affect the nutritive value of concentrate. The block making does not disintegrate the valuable nutrients either roughage or concentrate portion and keeping quality remain as such for longer period.

Table1. Livestock population trends in India (million)

Year	Cattle	Buffalo	Sheep	Goat	Others	Total	Poultry	Density /ha of net sown area
1951	155.3	43.4	39.1	47.2	7.8	292.8	73.5	2.45
1956	158.7	44.9	39.3	55.4	8.3	306.6	94.8	2.34
1961	175.6	51.2	40.2	60.9	7.5	335.4	114.2	2.48
1966	176.2	53.0	42.0	64.6	8.3	344.1	115.4	2.51
1972	178.3	57.4	40.0	67.5	10.3	353.4	138.5	2.58
1977	180.0	62.0	41.0	75.6	10.4	369.0	159.2	2.60
1982	192.5	69.8	48.8	95.3	13.2	419.6	207.7	2.99
1987	199.7	76.0	45.7	110.2	13.6	445.3	275.3	3.32
1992	204.6	84.2	50.8	115.3	15.8	470.9	307.1	3.30
1997	198.9	89.9	57.5	122.7	16.4	485.4	347.6	3.32
2003	185.2	96.6	61.5	124.4	16.9	485.0	489.0	-

Source: Government of India (2004).

Table2. Fodder supply, demand and deficit (million tones) scenario in India up to 2025.

Year	Supply			Demand			Deficit					
	Green	Dry	Total	Green	Dry	Total	Green	%	Dry	%	Total	%
1995	379	421	800	947	526	1473	568	60.0	105	20.0	673	45.7
2000	385	428	813	988	549	1537	603	61.0	121	22.0	724	47.1
2005	390	443	833	1025	569	1594	635	62.0	126	22.1	761	47.7
2010	395	451	846	1061	589	1650	666	62.8	138	23.4	804	48.7
2015	401	466	867	1097	609	1706	696	63.4	143	23.4	839	49.2
2020	406	473	879	1134	630	1764	728	64.2	157	24.9	885	50.2
2025	411	488	899	1170	650	1820	759	64.9	162	24.9	921	50.6

Source: Patil *et al.*(2005)

Table3. Bulk density of common roughages

S.N.	Roughage Resources	Bulk Density (kg/Cubic meter)	
		As such	Blocks at 4000psi
1	Natural grasses	25.70	453.51
2	Wheat straw	93.99	421.51
3	Rice straw	24.75	395.51
4	Urd straw	59.32	543.12
5	Groundnut haulm	56.18	582.67
6	Stylo straw	28.26	485.91
7	Sorghum stover	42.40	559.89
8	Leucaena leaves	83.04	745.50

Source: Samanta et al (2003)

Table4. Saving of storage space by making feed roughages blocks

S.N.	Roughages	Stored as Such (cubic meter/quintal)	Stored in Block Form (cubic meter/quintal	% Reduction in space/quintal
1	Natural grasses	3.89	0.22	94.34
2	Wheat straw	1.06	0.24	77.35
3	Rice straw	4.04	0.25	93.80
4	Urd straw	1.69	0.18	89.34
5	Groundnut haulm	1.78	0.17	90.44
6	Stylo straw	3.54	0.21	94.06
7	Sorghum stover	2.36	0.18	92.37
8	Leucaena leaves	1.20	0.13	89.16

Source: Samanta et al (2003)

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STRESS MANAGEMENT IN DAIRY CATTLE FOR OPTIMUM PRODUCTIVITY

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Indian dairy industry is emerging as a sunrise industry. India is first in milk production in the world production, 78 million MT of milk (per capita availability of 220 gm) from 57 million cow's 39 million buffaloes. This was possible only due to large scale crossbreeding of local breeds and non descript breeds of cattle. Now crossbred cows are emerging as in important dairy animals. Nearly 9 to 11% of all the cows in milk are crossbred. The total crossbred female cattle population including young stock was estimated to be abut 10 million in 1990. The crossbred animals are more susceptible to heat stress.

In India, the summer temperature goes beyond 45^0 C which is 18^0 C above the upper critical temperature of dairy cattle. (27^0 C The beginning of heat stress). When the temperature exceeds 27^0 even with low humidity, the temperature is above the comfort zone for the high producing dairy cows. Armstrong. (1994) in tropical countries like ours one may imagine the fate of animals during summer months when the temperature ranges between 35 to 47^0 C and relative humidity recorded up to 80-95 per cent. At high ambient temperature the animals waste their feed energy in Panting and Sweating the nature's way of cooling animals by evaporation. During summer the milk production is reduced to the extent of 50%. The crossbred / exotic animals are more prone to the heat stress losses as compared to indigenous cattle.

Armstrong (1994) reported following responses in animals during heat stress

1. Reduced feed intake
2. Increase water intake
3. Change in the metabolic rate / maintenance requirement.
4. Increased evaporative loss
5. Changes in blood hormones concentrations.
6. Increase body temperature.

There are several factors, which influence the severity of heat stress

1. These include
2. Environmental condition
3. Level of production & feed consumed
4. Stage of lactation
5. Cooling management.
6. Exercise requirements
7. Breed and Body colour

All these factor influence heat production, degree of stress she is subjected to and how effectively the low dissipate heat. These factors collectively get reflected in milk reflected in reduction in milk yield and reproduction efficiency. This productivity loss during summer can be reduced substantially by adopting the following heat stress management coupled with good health management.

1. Proper Summer Oriented Hosing
2. Animal Cooling System
3. Development of Breeds Tolerant to Heat Stress
4. High Energy Feeding.

Armstrong (1994) reported that by evaporative cooling, the cow produced 7.5 kg extra milk per day when the ambient temperature was about 40.5^0 C (RH less than 30%). Igono *et.al* (1987) observed that cows cooled with spray and fans under shade produced 2 kg / cow / day more milk compared to the cows in shade alone. Blackshow an Blackshaw (1994) recorded that no shed environment caused depression in milk production to the tune of 3.3 kg / day/ cow in predominantly black cows.

How evaporative cooling works?

Rise in ambient temperature activates sweat glands to produce sweat. Each gram of sweat evaporated from skin utilises 590 calories from skin surface (Latent heat of evaporation of water). This process of evaporation causes cooling of skin. A part form sweating animals increase their respiration rate. (Induced evaporation of moisture from mouth/ lungs). Breathing of animals at a much faster rate to combat heat stress leads to panting. To reduce the metabolic heat load, animals reject feed and fodder.

Proper animal housing

The cow sheds in Indian conditions must be designed to reduce the heat load because heat stress cause more damage to animals compared to winter. Animal can tolerate winter condition up to 15^0 C without any difficulty. But the summer above 30^{0}C result in drop in milk production and breeding efficiency. Therefore our cattle's specially crossbreds must be provided with proper housing. Theoretically speaking, the best type of animal shelter is a one where the micro-environment temperature remains within 15 to 25^0 C and humidity level around 10-12 mm Hg. Shades of trees provides an ideal protection from radiant heat, but do not fit because of other reasons.

Principles for creating an optimum micro-environment within an around the sheds are directed to reduce heat gain and promote heat losses from structure of animals house by radiation & condition. The point needs to be considered are:

(1) Orientation

Shed with its long axis running East - West provides a cooler environment than one with a North-South orientation (Kellyl *et al*, 1950). In the East- West oriented shelters animals get more opportunity for radiation exchange with cooler north sky. The shelter is shaded for a greater part of the day resulting into lower floor temperature. Thus this orientation favours heat loss from animal body to environment both by radiation and conduction.

(2) Shelter Design

Open type of sheds has advantage over closed type shed. Mean temperature and minimum temperature in close shed was significantly higher than those of open type shed. The close type shed significantly contributed to higher ambient temperature during both hot dry and hot humid months i.e. from April to September. The mean vapour pressure in close type shed have been reported to be higher than open type shed. (Singh *et.al.* 1977 and Singh *et. al*, 1985).

(3) Width and size of shelter

Slightly more shaded area than the minimum recommended floor space required for different species of livestock should be provided in hot dry climate. Floor space requirement for calf is 1.5 to 2 m^2, Adult male 7.0 m^2 and for adult female is 4.0-5.0 m^2. Optimum width of the shelter is 5.0-6.0 m. although wide shelter results in lower ground temperature underneath it and thus the amount of radiation from ground to animal body is reduced. Yet is simultaneously restricts the radiation from animals to cooler sky during night. Length of shelter depends on requirements. Ensure minimum cow stand of 5.5 x 9.0 feet with Pacca and well drained floor. Shaded resting area of about 30-40 square feet/ animal.

(4) Height of Shelter:

Minimum roof height should be 10.0 feet to reduce heat load. The height of shelter in hot climate should be between 3.0 - 5.0 m. A height less than 3.0 m interferes with proper ventilation resulting into reduced convective heat loss from animals. The shadow size is not affected by height since higher the shade the faster the shadow more. The impedance of the total sun and sky radiation at 3.5 m height is 61% against 64% at 2.2 m height. A too high shelter without providing any significant additional benefit involves high cost of construction.

(5) Shape and type of roof

The shape of the roof can be either flat, slopped or "A" shaped. "A" shaped roof is definitely better than a flat roof in hot climate. One side of "A" shaped roof saves the other half form direct solar radiation by casting its shadow. This helps in cutting down heat gain from roof.

Roof - may be either single or double with both the roofs of same or different materials.

(6) Roofing material

It may be Hay or Straw, Galvanised steel, Plywood and several types of plastics are the roofing material. On a typical summer day differences in radiant heat load under shades covered with straw and galvanised iron or plastics were of the order of 163 K cal/hour/ m^2 of animal surface. A 4-6 inch thick hay thatch does not receive much heat from the upper surface by conduction. The surface convective co-efficient of the hay, because of its uneven surface is also high. Hay thatch is more suitable for hot dry climate than hot humid climate (need for frequent removal of thatch is limiting factor). Wood makes good shed material but in it cracks develops and it needs treatments frequently. Asbestos sheet are more effective as top layer in double roof shelter.

(7) Shelter surroundings

Surface around shelter are very important in view of radiation exchange between different surfaces and the shelter. The temperature of different surfaces varies significantly at same air temperature. It is clear that green surface do not heat up as much as other surfaces like gravel or loose loam. It is difficult to maintain green vegetation adjacent to animal shelters. It may be possible to increase animal comfort by selection of proper type of unvegetated ground surface. These vary significantly in view of the difference in reflectivity, thermal conductivity and density etc.

(8) Ventilation:

Proper ventilation at ridge level keep two or three walls open.

(9) Colour of roof and walls

It should be white out side and coloured inside Reflectivity of white colour is around 75%. The reflectivity of the underneath surface should be less at it determines the quantity of incidental energy from the ground which will be reflected back down to the animals. Radiant heat load on the under surface of an aluminium roof having white paint on top and velvet -black inside was observed to be about 13 BTU/ feet^2 / hour less than unpainted roof made of the same material. Painting of side walls white from outside reduces the surface temperature of the walls inside by 12 to 22^0 C in comparison to unpainted walls at air temperature of the walls inside by 12 to 22^0 C in comparison to unpainted walls at air temperature above 37^0 C.

Water troughs should be kept under shade ensuring 24 hours water availability.

Feeding and nutritional management

Points to be consider while feeding animals during hot weather, as feeding frequency, (extra feeding) time of feeding, (cooler time of a day, adequate feeding space and plenty of cool water. Modification in ration can help to minimize the drop in milk production, decreasing forage to concentrate ratio, result in more digestible rations. Feeding buffers such as sodium bicarbonate and magnesium oxide allow higher concentrate rations and can help in low fat milk syndrome also. Hot weather increases the need of certain minerals. Do not overfeed highly degradable protein during hot weather it should be 18% or less. Supplemental fat can be added in ration to increase energy in take. Also avoid feeding excess fat, over feeding causes problem with rumen function supplementing extra vitamins during summer has no added advantage.

Animal cooling system

Use of water as cooling agent either directly on animal body or for cooling the shelter micro environment is as widely accepted practice. Water can be used for spraying the floor and roof of shelter periodically or continuously during peak hot hours which lower their temperature and consequently reduces the heat load on animals. Grass screens on sides of shelter when with water considerably cool down the air passing through them. It requires proper cross ventilation.

During summer, we can reduce heat load of animals artificially by spraying small quantity of water on their body at repeated interval of 15-30 minutes. Fans or blowers fitted in cow she help in increasing rate of evaporation of water. Skin cooling to the extent of 8 to 15^0 C is achieved depending upon relative humidity. Each gram of water evaporated takes away 560 calories of heat- the phenomenon of

Zero energy cooling

Cows having access to sheds with evaporated coolers had marked higher breeding efficiency than cows having access to only conventional sheds. The milk production is group maintained under cooled shed was 1.8 kg more per head than in conventionally shaded group.

The NDDB, Anand has developed a cooling with an estimated cost of Rs. 5000/- per set suitable for 6-8 milch animals. The results of the same system used for cooling Holstein cows are presented in table. It required a power of Rs. 400/- per summer which comes to about Rs. 50/- per animal which results in increase in milk production of about 1 to 1.5 kg per animal per day.

Conclusion

Proper cooling management and feeding of balance ration to cows in hot weather can provide good return on investment.

IMPACT OF DROUGHT ON REPRODUCTION AND FERTILITY IN ANIMALS

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Drought occurrence in arid region of Rajasthan is a regular phenomenon. It is used to be a typical tropical drought, being associated with high ambient temperature. In spite of recurrent droughts, animal husbandry is the backbone of arid rural economy being blessed with best drought hardy breeds of cattle, sheep, goat, horse & camel. Further, the livestock population is continuously increasing as a result, there is tremendous pressure of livestock on land.

In a broad term, applicable for a livestock keeper, drought is lack of sufficient precipitation at the time of year in which plants are dependent upon the moisture for growth. As a result, there is drastic decrease in forage production, both in terms of quality as well as quantity. The tropical drought is always associated with direct effect of heat stress on animals apart from fodder scarcity conditions.

Plant response to drought

Leaf & shoot growth slows as soil water becomes less available. Tillering in grasses is also reduced. As drought condition persists, leaves wilt, fold, discoloured and may eventually die. Thus there is drastic reduction in total amount of plant biomass availability. During drought plant utilize carbohydrates that were produced the previous growing season and stored in the roots or crown of the plant. This results in decrease in carbohydrate content of the already reduced biomass. This drain on stored carbohydrate result in loss of root vigour and fewer basal buds develop for the next year growth. Thus, drought can result not only in reduction in forage in the year of drought but also in subsequent years, even if rainfall is adequate (Blaine).

Affect of drought on animal performance

Low forage production results in livestock having to range further to obtain necessary amounts of dry matter to meet their nutritional needs. These extra efforts result in the expenditure of additional energy that may result in a loss of body condition for mature animals and reduced growth rate in younger stock. Walking in search of feed & water can use up as much as 30% of the energy a cow derives from feed (McDougald et al 2001).

If a cow or ewe is not able to obtain sufficient nutrients, particularly energy, she will loose considerable weight. A loss in body condition of a lactating cow or ewe results in a decrease in milk production and reproductive activity may cease. Body condition scores (BCS) of a cow 4-10 yrs of age needs to be above 4 & for a ewe 3-7 yrs of age & above 3 at time of parturition and breeding otherwise they will have lower milk production & fertility resulting in birth of underweight offsprings & in fertility (Wikse Herd, 1995). For survival loss of body weight upto 20% in cattle & 30-40% in arid sheep & camel is reversible. In general, animals that loose 30% or more of their normal body weight will nearly always die (Young & Scrimshaw, 1971).

Effect of drought on Reproductive potential

In nature it is general rule that animals breed annually and for the first time when it is attain a specific body weight. Parturition occurs when food for the mother is abundant to ensure adequate lactation for the nourishment of the offspring. Under the condition of housing & feeding provided by domestication, the breeding season tends to be lengthened as a result animals (bovines) may breed at any time of the year. All domesticated animals however show a tendency to revert to the natural breeding season (Arthur et al, 1989). Recurrent droughts of the arid region, force the animals to revert to the natural breeding rules i.e. 'improper nutrition- no breeding' to a certain extent.

In farm animals successful reproduction is considered gateway to milk production from animals as lactation follows successful reproduction only. Hence optimization of reproduction is the key for profitability from animals. Normal fertility, in general sense as applicable to cattle, denotes one viable calf each year. Infertility is simply a degree of reduced fertility.

Infertility in large animals is the result of several factors which include genetics, nutrition, environment, herd health status and production potential of the cow herd. The task of minimizing the negative effects of these factors on fertility is compounded because they do not act independently of each other.

Drought affect the reproductive performance of animals by the interaction of the above factors only, mainly through prolonged conditions of negative nitrogen balance and of heat- stress.

The important causative agents of the adverse effects of drought on reproduction are as follows-

1. Malnutrition
2. Environmental stress
3. High incidence of parasitic infestations
4. Higher incidence of diseases

(I) Effect of Malnutrition on reproductive potential- as discussed above drought has direct effect in lowering the nutritional status of animal i.e. malnutrition. Nutrition is the most critical factor affecting reproduction. To be specific, drought affected forage biomass contain lower concentration of Crude Protein, Energy, Vitamin- A & Phosphorous along with micro-elements. All these nutrients have direct role in maintaining normal reproductive potential.

Most of the field infertility cases in the arid region, especially during drought years, are usually due to multiple deficiencies of the above nutrients compounded with environmental heat- stress which directly ceases ovarian cyclicity.

The initiation of puberty is largely a function of the animals age & maturity since the female is born with a genetic potential for cyclic reproductive activity. Normally the females of domestic species reach the age of puberty at a specific age who in turn is closely related to body weight. Thus, the animals that are well fed with good growth rates reach puberty before those that are poorly fed with slow growth rates. However, unless the animal is severely malnourished the onset of cyclic activity will eventually occur (Arthur et al, 1989). Delayed skeltol maturity resulting from underfeeding can result in decreased pelvic width leading to dystokia which may further lead to increased post-partum interval and decreased conception & pregnancy rates (Walker et al, 1994)

(a) Protein Deficiency:- Prolonged drought condition lead to hypoproteinemia which otherwise, is also a condition of common occurrence in cattle, reported as infertile cases in rural arid areas. It is commonly associated with inanition & starvation condition of cattle. The effect of low level of protein intake on reproduction may be due to reduced intake of total feed resulting in delay in oestrous (Wiltbank et al, 1965).

(b) Hypoglycemia:- Reduced level of energy in animals during drought condition is common. It is due to existing lower levels of energy in the available forage biomass and additional energy loss by animals in search of such biomass in otherwise harsh arid environmental conditions. The level of energy is considered more important for reproduction than is protein. When the energy in the adult animal is low, follicle fail to develop to maturity resulting in follicular atresia along with a loss of sexual desire and anoestrous. (Roberts, 1971).

Hypoglycemia at estrus and shortly after service may exert a harmful effect on conception (Mcclure, 1968). This effect may be brought about by lowering of glucose or glycogen levels in the mucosa of genital tract resulting in a lack of energy for spermatozoa or fertilized ova.

(c) Vitamin-A deficiency:- Clinical symptoms of Vitamin-A deficiency are wide spread in arid region in general, but are pronounced during drought. The animals usually suffer from lacrimation, night-blindness, debility, thriftyness of skin coat along with abortion & still-birth incidences. There is controversy regarding role of Vitamin-A with anosterous condition. The deficiency effect occur during later half of gestation and are characterized by abortion or by the birth of weak or dead calf. Vitamin-A deficient animals may have normal oestrous cycle, ovulate & conceive with normal early fetal development even though epithelial or other tissue changes have developed (Roberts, 1971).

Vitamin-A deficiencies results in degenerative changes in epithelial tissue like keratinization & degeneration of the placenta which may lead to fetal death, abortion, dystokia, retained placenta & septic metritis.

Though β-carotene is the plant precursor of Vitamin-A, recent studies have shown separate importance of β-carotene & Vitamin-A. Bovine luteal tissue has one of the highest concentrations of β-carotene as compared to any other tissue but controversial role of β-Carotene deficiency in cases of delayed estrus, silent estrus, follicular cyst, LH & progesterone concentrations have been reported (Arthur et al, 1989).

But based on the response to the line of treatment of true anoestrous cases in drought affected rural arid region by us, Vitamin-A supplementation is considered very important in dealing with such infertility cases (Mathur et al, 2001). McDougeld et al (2001) have also considered Vitamin-A supplementation as critical during drought.

(d) Phosphorous deficiency:- Phosphorous deficiency symptoms are quite common and widely spread in animals of the arid areas. The symptoms include inanition, poor hair-coat, depraved appetite and infertility in form of delayed puberty, silent estrus, post-partum anoestrous with ovarian acyclicity or sub-dued activity. Source of phosphorous deficiency is considered to be the arid soil.

Phosphorous supplementation through inorganic/organic salt injectables and mineral mixtures in such infertility cases in the region has saluting effect. Hence, Phosphorous supplementation has been an important constituent of package for treating true anoestrous in the bovines of rural arid region (Mathur et al, 2001).

Role of Phsophorous in successful normal reproduction is well documented (Morrow, 1969; Read et al, 1986ab) but the evidence for the importance of hypophosphatemia as a cause of infertility is conflicting (Arthur et al. 1989). Morris (1976) suggested that a blood Phosphorous level of less than 4mg/dl in infertile animals at its peak production level confirms the diagnosis of hypophosphatemia as cause of infertility. Meeting out the normal phosphorous requirement for body maintenance of 13gm/day (requirement for milk production extra) from the drought affected forage biomass of the already phosphorous deficient arid soil seems to be unexpected.

(e) Trace minerals deficiency:- Specific Trace minerals namely Copper, Cobalt, Manganese, Iodine, Selenium and Chromium are considered to have role in maintaining reproductive potential but their direct role in the reproduction process is a subject of contradicting reports. Improvement in the fertility by their supplementation to infertile animals speaks of their importance. The deficiencies of these trace minerals are considered much higher in arid areas especially during drought conditions.

(II) Affect of environmental stress on reproduction during drought:- In majority of arid areas animals are mostly maintained on extensive grazing on range lands where these animals are not provided any kind of shelter during grazing/browsing except of natural trees. The average grazing period in arid region is about 10hrs/day. It has been estimated (Patel,2003) that about 80% arid farmers provide thatched house for cattle & buffaloes while only 10% farmers provide thatched house for sheep & goats during evening & nights after return from grazing.

Thus under the normal managemental conditions the animals under arid region are subjected to high degree of heat-stress involving solar radiation, wind velocity, air temperature & humidity. Livestock being homeotherms looses lot of energy under such stress conditions to maintain homeostasis through direct involvement of Central Nervous System and endocrine system which are also directly involved in controlling reproduction process. Thus there is direct effect of heat- stress on hypothalamus- pitutary axis which in turn controls gonadal activities.

(a)Heat-stress & fertility:- Heat stress is the major contributory factor to the lowered fertility in bovines affecting both male & female fertility . The conception rate in cattle are 20-30% lower in hot season (compared to winter season) alongwith lowered incidence of estrus detection, day to first service (Cavestancy et al, 1985; Badinga et al, 1985; Rensis et al, 2002; Almier et al, 2002).

It has been suggested that there could be longer lasting effect of heat stress of summer months on the antral follicles that will develop into large dominant follicles 40-50 days later (Roth et al, 2001 ab). In general, heat-stress reduces the duration & intensity of estrus in dairy cattle (Rensis & Scaramuzzi, 2003). Reproductive efficiency is well known to be decreased during summer months both in male & female buffaloes (Bhattacharya et al, 1970; Pant & Roy, 1972; Luktuke et al, 1973; Sengupta & Bhela, 1988).

(b) Effect of heat stress on reproductive hormones:- There is direct effect of heat stress on hypothalamus pituitary axis controlling gonadal activities. The effect of heat-stress on LH concentrations in peripheral blood is inconsistent. It has been concluded (Rensis & Scaramuzzi, 2003) that in summer the dominant follicle develops in a low LH environment which results in lower estradiol secretion from the dominant follicle leading to poor expression of estrus and hence reduction in fertility.

FSH is increased by heat-stress, may be due to decreased plasma Inhibin production by the compromised follicles. It is indicative of reduced folliculogenesis since a significant proportion of plasma Inhibin comes from small & medium sized follicles (Wolfenson et al, 1995; Palta et al, 1997).
The effect of heat stress in reducing plasma estradiol is clear but its effect on plasma progesterone is controversial. The effect of heat stress in reducing secretory activity of follicles (hence reduction in estradiaol concentration) leading to summer infertility is perhaps through increased corticosteroid secretion which can inhibit GnRH & LH secretion (Gilad et al 1993).

(c) Effect of heat stress on Follicular development:- Recent evidence indicate that the development of oocytes is also temperature sensitive (Ruteledge et al, 1999) indicating possibility of high ovarion temperature during heat stress. Heat stress delays follicle selection & lengthens the follicular wave and thus has potentially adverse effects on the quality of oocytes & follicular steroidogenesis (Roth et al, 2001ab). Summer heat stress reduces the degree of dominant follicle and more medium sized dominant follicles survive (Woolfenson et al, 1995) as a result more than one dominant follicle can develop leading to increase in twinning rate (Ryan & Boland, 1991)

(d) Effect of heat-stress on embryo survival:- Heat stress has reported to result in decrease in blood flow to the uterus and increase in uterine temperature (Roman-Ponce et al, 1978) which inhibit embryonic development leading to early embryonic mortality but the magnitude of the effect decrease as embryo develops. Most embryo loss occurs before day 42 in heat stressed cows (Ealy et al, 1993; Vasconcelos et al, 1998). Heat stress can affect endometrial prostaglandin secretion leading to premature luteolysis & embryo loss.

Thus heat stress has a wide range of effect on the reproductive axis. Some of these effects directly affect individual reproductive organs such as hypothalamus, anterior pitutary, the uterus, the follicles with oocytes and the embro itself. The indirect effect of heat stress are resulted by the reduced dry matter intake & prolonged negative nitrogen balance. Thus the overall effect on fertility is due to accumulation of the effects of the above several factors (Rensis & Scaramuzzi, 2003).

(III) Effect of drought on Parasitic infestation:- Cattle of all ages under nutritional & heat stress are resistant to parasites than under normal condition. It is applicable for both internal & external parasites hence strategic deworming during a drought will relieve some of the nutritional stress on the animal (Hupp &

Rathwell, 1998). There is already a higher load of parasites in the arid livestock due to availability of scarce & unhygienic water supply from the common rural ponds.

These high incidences of endo & ectoparasitism cause further precipitation of nutritional deficiencies in the already underfed animals during drought. Hence it is advisable that before start of any nutritional supplementation programme to combat infertility during drought, control of both endo & ectoparasites, should be taken up as a pre-requisite step in the arid region.

IV. Disease incidence during drought affecting reproduction:- Any general/ specific infectious or non-infectious disease incidence occurring during drought lowers the nutritional status & general resistance of the animal which in turn affect the reproduction process to varying extent. Such affections are-

(a)Infectious diseases:- As cattle graze on shorter & shorter forage during drought, the chance of picking up soil- borne pathogens like Clostridial diseases (Black Quarter & Enterotoxemia), Leptospirosis & Anthrax increases (RonGill). Under prevailing Indian conditions incidences of HS & FMD may also be kept in mind.

(b)Non-infectious diseases- (i) Deficiency diseases:-Ketosis, Anaemia, Pica, milk fever, Grass tetany, Xerophthalmia, Ricketts, Osteomalacia, Goitre, Parakeratosis, Hypocuprosis etc.

(ii) Malnutrition linked diseases:- Stomatitis, Gastroenteritis, indigestion, Tympany, Hepatitis, Nephritis & urolithiasis, Post-parturient Hemoglobinuria (hypophosphatemia), Choke, Traumatic Reticlo Peritonitis, dehydration etc (ICAR).

(iii) Heat Stroke/ Sun Stroke:- The condition may be sudden preceded by ataxia, weakness, hot skin, rapid pulse & high temperature (upto 107 F) and death (ICAR).

(iv) Poisoning & Toxicity:- Starvation condition may lead to eating of poisonous toxic material like braken fern, lantana, camara, Rati (Abrus prectorus), Dhatura, Kner, cyanogenic plants like immature sorghum, maize & cereals affected with ergot, India Pea, Nitrate & Nitrite containing plants (ICAR).

Strategies to moderate impact of drought on livestock production & fertility

(I). Culling of animals:- In conditions of threatened drought, attempt should be made to reduce the livestock numbers in a planned systematic method. Dry & unproductive animals need to be culled first. Destocking of animals shall conserve the limited feed & fodder resources for the more productive animals. Culling policy during drought has been mentioned (Blaine) but its practicability is difficult under Indian conditions due to religious & cultural compulsions.

(II) Segregation of animals:- As heifers & calves are not able to compete with mature cows for pasture or supplemental feed, their segregation into suitable groups shall provide them a better chance of getting needed feed supplies . Vulnerable classes can be segregated & given preferential treatment. The older cows can be moved to the poorer forage fields. (Hupp & Rathwell, 1998).

(III) General Livestock Managemental Practices:- The important managemental practices which are to be adopted during drought condition are given below (ICAR)-

- Animal should not be kept in direct sunlight; they should be tied under a tree or in a shed.
- They should be allowed to graze only in early morning or late evening. Supplementation of feed & fodder should also be done during this period to decrease water requirement.
- There should be no overcrowding of animal in shed and animals should be provided proper ventilation.
- Roof of the shade should be better made of asbestos sheet. Roof made of iron sheets need to be covered with thatching material.
- Upper layer of Kaccha floor should be replaced with new sand in every six months so that load of organism can be reduced.
- Pakka floor should be properly cleaned and as per need disinfectant may also be used.

- Wild animals like fox, dogs, jackals who are responsible for spread of some infections like rabies, anthrax, FMD, HS etc. need to be controlled.

IV. Feeding strategies during drought- During drought malnutrition lead to loss of body weight. In case of milch & other producing animals, the only solution lies with supplementation because productivity loss cannot be recouped by any other mean.

The strategy in this regard may include-

- Storage in fodder banks
- Urea treatment of straws
- Supplementation of Vitamin-A & mineral mixture
- Complete feed formalities
- Use of dry & fallen tree leaves.
- Use of unconventional feed resources.
- Water management.

IV. Preventive measures against epidemics & diseases-

(I) Control of endoparasites- by deworning with broad spectrum anthelmentre like Albenda zole, fenbenazole & Oxefendazole atleast teice a year.

(II) Control of ectoparasites- like tricks, mites etc. by regular spray of deltamethrin (0.2% solution) or Cypermethrin (0.1% solution). For spray in the shed, the concentration needs to be at least 5 times more. The usual precautions for use of insecticides must be taken.

(III) Vaccination against prevalent infectious diseases- like FMD (Polyvalent FMD Vaccine), HS (HS oil Adjuvent Vaccine), Anthrax (Anthrax spore vaccine), BQ (BQ Polyvalent Vaccine), Enterotoxemia (ET Vaccine), Sheep/goat Pox, PPR in goat (IVRI Vaccine)etc.

(IV) Coccidiostat- All calves at 0-3 months should be given Coccidio stat, mainly sulfonamides @ 220mg/kg b.w. on first day & @ 110mg/kg b.w. for the next four days should be given (ICAR).

(V) Management of heat stroke-

(a) The affected animal should be moved to shade and Ventilated areas.
(b) Water should be poured on the body.
(c) Fluid therapy to check dehydration should be done in consultation with Vet. However, self- made preparation containing 10 litres of cold water properly mixed with 0.5 litre molasses or 0.5 kg jaggery, 20 gm common salt 0.5 kg oat or barley flour can be given orally twice daily for 2-3 days (ICAR).

(VI) Poisoning & Toxicity control- Locate all areas with poisonous plants and monitor them closely and prevent their access to the grazing animals. In general, toxic symptoms are seen in many animals of the flock/herd with specific symptoms which require specific antidote, several fluid therapy & injectable atropine sulfate through veterinarian.

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SHRUB AND LEGUME BASED PASTURES FOR SUSTAINABLE ANIMAL PRODUCTION – PROBLEMS AND PROSPECTS

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Introduction

The hot arid tropical zone of India covers about 12 per cent of the country's geographical area, and occupies over 3.2 lakh sq. km of land located in parts of Rajasthan (61%), Gujarat *(20"10),* Andhra Pradesh and Karnataka (10%), and Haryana and Punjab (9%). The human (23m) and livestock (20.5 m) population in this region. Even in normal rainfall year there is shortage of 36, 79 and 94 percent of dry forage, green fodder and concentrates respectively for the livestock in Western Rajasthan and the animal feed shortage rises to 80 to 95% in drought year. To improve animal feed availability in the region besides fodder production from cultivated lands we have to improve the productivity of grazing lands (10 m ha) which is at present dismally low (0.35 t/ha). If not properly developed and scientifically utilized, these lands will continue to accentuate the process of desertification and soon may lead to serious environmental problems even for other parts of the country. CAZRI based on its over four decades of research has come out with full package of pasture establishment and utilization techniques for various sub-agro-climatic regions pertaining mainly to pasture grasses like *Cenchrus ciliaris, Cenchrus setigerus, Lasiurus sindicus, Dichanthium annulatum* and *Panicum antidotale* (Daulay and Bhati 1989). Although at this Institute research work on adaptability and grazing behaviour of some of the pasture legumes viz. *Clitoria ternatea, Lablab purpureus, Indigo/era !>pp.* has also been conducted. Several exotic pasture legumes viz., *Macroptilium atropurpureum* (Siratro), *Lotononis bainesii, Desmodium intortum, Centrosema pubescens, Stylosanthes hamata,* S. *scabra, S. viscosa,* S. *guianensis* were also studied for their adaptability in this tract. Except *M. atropurpureum* non had shown much promise.

Fortunately nature has gifted these challenging areas with highly productive and useful species of pasture legumes and shrubs. There is great scope of optimal integration of legume components with pastoral grasses to increase the productivity, nutritive value, grand growth Phase and palatability, on these pastures. Besides the pasture legumes can also fix the atmospheric nitrogen in the soil, thereby improving the productivity of grass component through biological N-fertilization. The response of pasture grasses to nitrogen application is well recognized (Bhati & Mathur 1984) & proper integration of legume components with pasture grasses can help in the productivity enhancement of grasses through effective use of nitrogen fixed by the pasture legume component.

A. Experimental findings

Experimental findings of some of the studies carried out at this Institute (Bhati *et al.* 1987) on various aspects of legume/shrub grasslands viz., germination, nodulation, compatibility, establishment and animal grazing are presented below for better comprehension of this important area of research.

Germination: Amongst pasture legumes the germination percentage of one year old seed of *Stylosanthus humilis,* (16.0%) and *Indigofera cordifolia* (19.0%) were very poor as compared to *Atylosia scarabaeoides* (87.0%), *Lablab purpureus* (72%), *Macroptilium atropurpureum* (79%) and *Clitoria ternatea* (65.0%).

Nodulation: *L. purpureus, C. ternatea* and *M. atropurpureum* nodulated very profusely (Table I) in the field conditions. The per cent soluble sugar (2.09 and 3.62%), dry weight of nodules (122.15 and 38.67 mg/plant) were higher in *L. pulrpureus* and C. *trnatea* respectively, thereby, revealing their better nitrogen fixing ability. The result in general revealed that the pasture legumes viz. *L. purppurus, C. trnatea* and *M. atropurpureum* hold great premise for better establishment and biological nitrogen fixation in development of legume based pastures in tree arid regions.

Compatibility: Investigations carried out to assess the feasibility of grass-legume association revealed that L. *purpureus* failed to regenerate while *Clitoria ternatea* continued to persist in association with perennial grasses viz. *L. sindicus* and C. *ciliaris* even during IIIrd and IVth years of establishment. Higher yields of forage were recorded in *L. sindicus* and C. *ternatea* (2: 1) combinations.

Table 1. Abundance and chemical composition (%) of nodules in pasture legumes.

Pasture Legume	No. of effective nodules/ plant	Fresh wt. of nodules/ plant	Dry. wt. of nodules / plant	Moisture %	Soluble sugar %	Nitrogen %	Starch %	Reducing sugar %
Atylosia scarabaeoides	9.84	19.23	16.48	16	3.04	36.54	1.28	0.05
Indigofera cordifolia	6.88	4.44	2.44	45.04	-	56.70	-	-
Lablab purpureus	29.2	423.00	122.15	71.92	2.09	41.79	0.27	0.07
Macroptilium atropurpureum	11.6	74.0	21.6	70.81	1.65	53.27	1.79	0.10

Soil and Water Conservation: Protection from biotic factors and adoption of improved soil and water conservation measures (gully control, staggered contour trenches, vegetative barriers etc.) could result increase in the density of several naturally occurring shrubs in rocky degraded grasslands substantially in a period of 5 years (Table 2). The increase in density was highest (872%) in *Ziziphus nummularia* and was least in *Grewia tenax* (187.5%). All these shrubs are very important for improvement in nutritive value of the fodder produced on one hand and imhancement of grazing period by 1 to 2 months on the other.

Table 2. Increase in the density of natural woody perennials under protection and soil and water conservation measures after 5 years (1988-1993).

Woody perennial	Density (No.ofplants/30 ha)		
	Initial (1988)	Final (1993)	% Increase
Capparis decidua	103	315	205.8
Maytenus emarginata	41	221	439.0
Acacia jacquemontii	10	76	650.0
Lycium barbarum	36	193	436.1
Grewia tenax	8	23	187.5
Ziziphus nummularia	44	438	872.8
Total	266	1458	448.12

Legume-shrub grasslands: Preliminary studies on the role of shrubs in pasture lands was conducted by Kanl and Ganguli (1963) and they observed highest production (1.0 t/ha) on the natural grasslands of which 14% area was covered with Z. *nummularia* shrub. Sharma and Vashistha (1980) also reported highest forage yield (1.2 t/ha) in C *ciliaris* + Z. *nummularia* (210 p/ha) pasture. As a step forward in 1982-83 a full fledged research programme for evaluation of shrub/legume based pastures under animal grazing system (mixed flock of sheep and goat) was initiated at Jodhpur (av. rainfall 357.6 mm) with C. *ternatea* as a pasture legume and Z. *nummularia* as a shrub in varying proportions with C. *ciliaris* [A. 1:0 (pure grass), B. 1:1 (grass:legume), C. 2:1 (grass: legume), D. 1:1 (grass: shrub), E. 2: 1 (grass: shrub)] on a paddock of 0.75 ha size for each treatment

(Bhati *et al.* 1987). The grazing was initiated in the third year of establishment with 4 ram-lambs (Av. body wt. 96 kg/animal) and 4 he-goats (av. body wt. 68 kg/animal) per paddock and was continued for three growth seasons. The forage and seed productivity in different pastures during establishment phase (1982-84) are presented in Table 3. The observations clearly revealed that the pasture No. B to E besides giving acceptable levels of grass yield also produced highly nutritive fodder for the animals from the legume/shrub component. However, introduction of grazing in 1984 resulted heavy pressure specially on legume component and resulted in complete mortality of C. *ternatea* in pasture No. B and C. As such it appeared that the pasture legume although good for stall feeding may perhaps not be able to sustain the animal grazing pressure in arid zone conditions. Contrary to legume, Z. *nummularia* could sustain the heavy browsing pressure of animals well and no mortality was observed. The live weight gain and wool/hair production was higher in the pastures having these components (Table 4).

Table 3. Forage (t/ha) and seed (q/ha) productivity of legume/shrub pastures in establishment years (1982-84).

Type of pasture	Forage yield (t/ha)					Seed yield (q/ha)				
	1982	1983	1984		Total	1982	1983	1984		Total
	Grass	Grass	Grass	Legume /Shrub		Grass	Grass	Grass	Legum e /Shrub	
A. C. *ciliaris*	1.40	1.40	2.78	-	2.78	1.10	1.62	2.76	-	2.76
B. C. *ciliaris* + C. *ternatea* (1:1)	1.31	1.42	1.14	1.07	2.21	0.95	0.96	0.96	1.82	2.88
C. *C. ciliaris* +c. *ternatea* (2: 1)	1.42	1.31	1.49	0.46	1.95	1.04.	1.32	1.42	1.34	2.76
D. *C. ciliaris* +Z.*nummularia* (1: 1)	1.00	0.95	0.83	0.17	1.00	0.60	0.85	0.93	1.50	2.43
E. *C. ciliaris* +Z.*nummularia* (2.1)	1.20	0.90	1.62	0.17	1.79	0.80	1.45	1.18	0.89	2.07

Since all the three years (1984, 1985, 1986) have been the drought years the animal grazing could not be continued on year long basis and in lean periods animals were fed from outside fodder resources. It is therefore suggested that we should develop a three tier system involving top feed tree species, shrubs/legumes and grass component in suitable proportion for year long grazing and sustainability of animal production from these lands. In fact it can be an important area of pasture research programme.

Table 4. Live weight gain (kg/ha) and wool/hair (kg/ha) production from sheep and goat for legume/shrub pastures

Pastures	Lie weight gain (kglha)					Wool/hair production (kg/ha)				
	Ram lambs			He-goat		Ram lambs			He - goat	
	Dec. 84 to June 85	Oct. 85 to Dec. 85	Sept. 86 to Jan. 87	Dec. 84 to June 85	Oct . 85 to De c. 85	Sept. 86 to Jan. 87	Dec. 84 to June 85	Oct. 85 to Dec. 85	Dec. 84 to June 85	Oct. 85 to Dec. 85
A. C *ciliaris*	18.5	3.0	3.0	*22.0*	4.5	10.0	4.5	2.9	0.85	0.95

B. *C. ciliaris* *C. ternatea* (1.1)	19.0	-	-	*20.0*	-	-	5.0	-	1.25	-
C. C. *czliaris* . C. *ternatea* (2: 1)	19.5	-	-	*22.0*	-	-	4.1	-	1.20	-
D. *C ciliaris* *Z. nummularza* (1: 1)	*25.0*	13.0	9.0	23.5	16. 0	11.5	4.2	3.2	1.3	1.05
E. C. *ciliaris* + Z *nummularia* (2.1)	24.5	*16.0*	4.5	*24.0*	170	*16.0*	4.75	.3.1	1.35	1.25

B. Economic Evaluation

(i) **Establishment** Cost: Establishment of shrub based pastures was found. costlier than the pure grass pasture because of the added cost of shrub establishment The total expenditure towards the pasture establishment was Rs. 2187'00,2275.00,2058.50,4608.00 and 4241.50 for pasture numbers A, B, C 0 and E respectively (Bhati *et. al.*, 1987). Abnormal rainfall pattern in the establishment phase (1982-83, 1983-84) also added to the cost particularly in *Ziziphus* based pastures (Table 6). Further the establishment costs were calculated on hectare basis which are never applicable to grazing lands as they are usually of larger size (10 hectares and beyond). Therefore the establishment cost will reduce accordingly making them more profitable propositions as the size of pastures increase.

Table 6. Year wise grass monetary returns (Rs/ha) from legume/shrub grasslands.

Pasture	1982 - 83	1983 - 84	1984 - 85	1985 - 86	1986 - 87
A. C *ciliaris*	832.50	3520.50	1139.30	312.75	412.50
B. *C. ciliaris + C. ternatea* (1.1)	456.00	930.30	1125.00	-	-
C. C. *czliaris*+ C. *ternatea* (2: 1)	241.50	1919.40	1125.10	-	-
D. *C ciliaris+ Z. Nummularza* (1: 1)	51.75	1425.43	1295.40	881.50	600.00
C. *ciliaris++* Z. *nummularia* (2.1)	238.50	1652.80	1309.55	994.45	600.00

ii) **Gross monetary returns:** The monetary returns from these pastures were estimated on the basis of forage, seed, green leaf *('Pala')*, bushwood (fire wood), manure, wool/hair and live weight gain. Although based on 5 years of estimations pure pasture of buffel grass gave higher returns (Rs. 6226.50/ha) but the returns were also satisfactory from shrub-based pastures i.e. D (Rs. 4250.08/ha) and E (Rs. 4795.30/ha). Again the yield of shrub component is also bound to increase over time. Hence these pastures are expected to give better returns in long run. Further as reflected in Table 4 the live weight gain and wool production were also conspicuously higher in these pastures and this trend will continue to turn them more and more profitable with the passage of time. The year wise monetary returns from these pastures are given in Table 6. In 1985 and 86 the returns were calculated only on the basis of animal productivity and it clearly reflected the superiority of these pastures over pure grass pasture. Since the prices of wool and meat were low during these years i.e. Rs. 25/kg and 22/kg respectively as reflected in low monetary returns over previous years where higher seed price (Rs 25/kg for grass, Rs. 5/kg for legume) reflected in high returns.

Conclusions

From the foregoing discussion it is evident that nature has bestowed arid regions not only with highly productive and useful species of pasture grasses but also of legumes and shrubs. If properly dovetailed with pasture grasses these legumes/shrubs can help in 1 improvement in pasture productivity and quality, 2. enhanced palatability and grazing period, 3. improved soil fertility and productivity, 4. efficient soil and water conservation and ultimately; 5. socio-economic stability through enhanced livestock productivity and quality. Although Z. *nummularia* has been identified as suitable shrub in association with pasture grass *C. ciliaris* (1 :2), but there are many indigenous (*Calligonum polygenides, A. jegumontic, Mimosa hamata, Dichrostachys cinerea etc.*)and exotic (*Dichrostachys nutans, Colophmpermum mopane* etc.) shrubs which need to be evaluated for their suitability in development of shrub based pasture systems befitting different agro-climatic situations in the desert. Similarly there are several pasture legumes *Rhynehosia mixima, A. searabeoides, Indigopea spp. Etc.*)which need to be investigated for their compatibility and proportion with pastoral grasses both under stall feeding and grazing management At last it can be concluded that active people's participation is of paramount importance in development and management of these systems on community/private grazing lands.

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SILVIPASTORAL APPROACH TO COMBAT FODDER CRISES DURING DROUGHT

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Introduction

The world food scenario is becoming more and more complex with the demand of food increasing at higher rate from a scarce resource. India with 2.2% of the global geographical area supports about 16% of total human and 20% of livestock population of the world. However, the productivity of the livestock in India is lowest in world. The low productivity of Indian livestock is mainly due to chronic shortage of feeds and fodder coupled with poor quality the majority of livestock are maintained in village grazing land or other waste lands which are in extremely degraded stock of vegetation and nutritive value. These problems are more acute in hot arid region, which occupies major part of north western India (28.57 million hectare) leaving western part of Rajasthan (19.6 million hectare) Gujarat (6.72 million/ha) and south we4stern part of Haryana and Punjab (2.75 million/ha). This region receives low rainfall and has high evaporation and high temp with high wind velocity and low soil fertility. Rain fed agriculture combined with animal husbandry is the major basis of livelihood of desert dwellers. Frequent droughts result in failure of annual crops hence livestock enterprise is becoming more important in this region but availability of fodder is again bottleneck for livestock rearing the regions.

Livestock are valuable component of sustainable and economically viable farming systems of Rajasthan, endowed with huge livestock population which is at present 49.15 millions (livestock census 2003). Out of these, 21.92 million comprising 18.72% cattle, 14.59% buffaloes, 26.23% sheep and 38.10% goat are in arid districts of Rajasthan. The state contributes about 10% of milk, 30% of meat and 40% of wool production ink the country. Livestock sector in Rajasthan accounts 19% of state domestic products. The density of livestock except sheep and camel is less in arid region as compared to other part of Rajasthan. Thus, are per unit of livestock is more in arid region (1.82 ha/ACU) but fodder resources are much less than rest of state. Inspite of large grazing area (about 53% of total land in arid region) of western Rajasthan, fodder availability is not sufficient to feed 21.92 million of livestock (Census 2003). At present the requirement of total dry matter is estimated to about 39 million tones where as the availability is about 14-15 million tones of dry fodder and 8-9 million tones of green fodder under normal rainfall situation which is deficient to the extent of 40-50%. This may increase to 80-90% during extreme of drought years requiring large volume of import of fodder from neighboring states.

The increasing deficiency of fodder availability is due to decreasing and deterioration of pasture and grazing land coupled with declined in cultivation of crops producing fodder. During normal year, the dual purpose crops contributes major portion of fodder but in drought conditions fodder production from dual purpose crops is reduced resulting fodder crises in arid zone of Rajasthan under such situation silivipastoral system is growing grasses in association with multipurpose trees/shrubs could help in combating the fodder crises during drought by providing nutritious green as well as dry fodder

Silvipasture and its importance

Traditionally silvipasture is used to grass farming in forest enclosures, which accommodate millions of livestock for grazing on the herbaceous growth. Extending this principal silvipasture is the conscious practice of cultivation of forage crops along with fodder trees shrubs some what similar to Agroforestry or taungya system although the word silvipasture is new the practice of giving trees in the farm fields for their to feed value has been in vogue traditionally among the farmers of western Rajasthan. Their have encouraged and protected the population of *Khejri* (Prosopis cineraria) and *Bordi* (*Ziziphus nummularia*) in their crop fields to top them in winter for top feed and fuel wood. In simple world the term silvipasture denotes silvipasture pasture means grasses or grass + legume mixture but in real serve it is an ideal combination of grasses legumes and trees shrubs for optimizing land productivity conserving plant soil and nutrient and producing forage fuel wood timber etc. on sustainable basis. Thus this evolves re plantation substitution on intervention in the existing vegetation by desirable species (Deb Roy and Pathak, 1974). Recently Nair (1993) defined than silivipastoral system are land use system in which trees and or shrubs are combined with livestock and pasture for forage and fuel wood production on the same unit of land within this broad category several types of system and practices can be identified depending on this role of tree shrubs component viz, cut and carry system live fences post browsing and grazing etc.

Silivipastoral system has special significance in arid and semi arid region where there is levels vegetation and high rate of deforestation and land degradation due to low and erratic rainfall about 13% f land under potentially productive water lands a sustainable past of which can be reclaimed through silivipastoral system. This technology checks land degradation on one hand and provides much-recorded products viz. food, fiber, fodder and fuel wood, timber, medicine etc. on others hand.

Ruminants like buffaloes, cattle, goats and sheep are extremely important resources in the arid and semi arid regions of India, however, their productivity level by and large is extremely low because of low quality and seasonal nature of forage supply. The problem becomes more acute in dry seasons, In such situations, forage based silivipastoral system could be a promise. Besides, trees in silivipastoral system also provide shade to the grazing animals and serves as fences, hedge and wind breaks which intercept the wind blown particles and prevent solid erosion and conserve soil moisture silivipastoral system have potential to add organic matter to soil and improve soil structure of forage sandy and alluvial land forms.

Suitable Silvipastoral models for different land forms and rainfall situations

The selection of suitable species of trees/shrubs, grasses and legume for establishment of silivipastoral system depend on agro climatic condition of the regions. The following trees/shrubs and pasture species foe different land forms and rainfall zones are identified.

(A) Suitable species for silivipastoral system under different land form.

Type of land	Suitable species		
	Grasses	Legumes	Trees/shrubs
Desert land and sand dunes	*Lasiurus sindicus Cenchrus ciliaris Cenchrus setigerus*	*Lab lab purpureus Clitoria ternatea Atylosia scarabaeoides*	*Acacia tortilis, Acacia nilotica, Acacia Senegal, Prosopis cineraria, Prosopis juliflora, Azadirachta indica, Ziziphus nummularia, Colophospermum mopane Dichrostachys nutan,s Colligonum polygonoides*
Ravine lands	*Cenchrus ciliaris Cenchrus setigerus Dichanthium annulatum Pannisetum pedicellatum Saccharam spontaneum Chrysopogon fulvus*	*Stylosanthes* spp *Stizolobium decrigenum Macroptilium atropurpureum, Atylosia* spp	*Acacia tortilis Acacia nilotica Acacia catechu Albizia lebbek Albizia amara Dalbergia sissoo Zizyphus spp. Ficus spp. Emblica officinalis Eugenia jambolana*
Cultivable waste lands	*Cenchrus ciliaris, Cenchrus setigerus Pennisetum polystachyon Panicum antidotale, Sehima nervosum Clrysopogon fulvus Dischanthium annulatum*	*Macroptilium atropurpureum Glycina Jaranica Clitoria ternatea*	*Albizia spp, Hardwickia binnata Leucaena leucocephala, Acacia* spp. *Sesbania* spp., *Dichrostachys nutans, Prosopis cineraria, Ziziphus Mauritiana*
Salt affected area	*Cynodon dactylon, Paspalium notatum, Chloris gayana, Lasiurus sindicus Brachiaria mutica, Sporolobus marginatus, Urochloa*	Glycine javanica Macroptillum spp. Phaseolus junatea, stylosanthes	*Acacia tortilis, A. nilotica Prosopis juliflora, Salvadora spp Zizphus spp. Sesbania spp. Albizia amara Atriplex spp*

(B) Suitable species of grasses and trees on the basis of rainfall

Rainfall Zone	Grasses	Legumes	Trees/shrubs
Rainfall zone150 to 300 m	*Lasiurus sindicus, Cenchrus ciliaris*	*Lab lab purpureus, Clitoria ternatea*	*Prosopis juliflora, Acacia tortilis Acacia Senegal, Zizyphus nummularia. Colligonum polygonoides, Dichtrostahys nutans*
Rainfall zone 300 to 500mm	*Lasiurus sindicus, Cenchrus cilaris, Cenchrus setigerus, Panicum antidotale*	*Lab lab purpureus, Clitoria ternatea*	*Acacia. tortilis, A. nclotica P. cineraria Tecomella undulata Colophospermum mopone, Ziziphus spp. Colligonum polygonoides. Azadirachta indica H.binnata Ailanthus exelsa, Albizia lebbek*
Rainfall zone above 500 mm	*C. cilaris, Dichanthium* annutatum, *Chrysopogon fulvus, sehima nervosum, panicum antidotale, Heteropogon Contortus*	Stylosanthes	*Acacia nilotica, Acacia catechu Dalbergia sissoo Leucana leucocephala, Albizia spp. Alianthus excelsa Hardwickia binnata*

Forage Production of various Silvipastoral models

Forage yield from grasses grown in association with fodder-cum-fuel trees of various silvipastoral model varies depending upon soil and climatic condition. In traditional silvipastoral system, trees/shrubs are permitted to grow at random in fields on the boundary of the fields or community grazing land with grasses of low productivity and nutritive value. In arid zone of Rajasthan, Kaul and Ganguli (1963) recorded maximum combined yield of grass and Pala (1 t/ha) under 14% of land area covered with *Zizyphus* canopy. Similarly Ahuja (1980) recorded highest grass yield (1.1 to 1.5 t/ha) under *Khejri* and lowest (0.6 to 0.7 t/ha) under *Kumat* plantation of 14 to 18 year old with substantial contribution of *Cenchrus* and *Eleusine* species as under storey perennial grasses. The productivity and carrying capacity of grazing land can be increased through improved silvipastoral system. At Jhansi, Pathak *et al* (1996) reported that the degraded lands producing hardly up to 1 t/ha/year biomass, which can be improved up to 10 t/ha through silvipastoral system. A study conducted at NRCAF, Jhansi revealed that an average total biomass yield of 12.62 t/ha/year recorded under silvipastoral system consisting of *A. amara* and *L. leucocephola* as trees, *D. cinerea* as shrub and *C. fulvus+ S. hamata* as pasture was about 4 time higher than yield (3.16 t/ha/year) obtained from natural grassland (Rai *et al.*, 1999). *Silvipastoral studies undertaken at CAZRI, Pali involving four tree species, (Acacia tortilis, Azadirachla indica,* Albizia lebbek and *Holoptelia integrifolia*) and four grasses (*C. ciliaris, C. setigerus. D. annlatum and Panicum antidotale*) revealed non significance difference in the dry fodder yield under different tree species, however, the mean dry forage yield was maximum in *Dichanthium annulatum* (28 g/ha) followed by 25.1 g/ha in Cenchrus ciliaris and 22 g/ha in *Panicum antidotale* (Muthana and Shankarnarayan,1978). Silvipastoral studies at Jodhpur indicated that sowing of *Cenchrus ciliaris* under the cover *H. integrifolia* did not interfere with normal growth with an additional dry forage yield of 7 to 12 q/ha. In another study, Harsh *et al* (1992) reported that a mixture of *C. fulvus* and *Sehima nervosum* grass produced 3.25 t/ha forage under canopy of five year old *Hardwickia binnata.* Similarly Patidar (2006) recorded maximum herbage yield with LS + cowpea (90 and 31 g/ha) green and dry forage yield) followed by sole 25 (89 and 30.8 g/ha) green and dry fodder yield and CC+cowpea system (84.6 and 28.6 green and dry forage yield grown in association with c. mopane and H binnata. The forage yield was not different due to tree species, however, application of 40 kg N/ha enhanced fodder yield y 13-14% over control. Yadav and Poonia (2003) recorded maximum biomass yield of grasses and tree from silvipastoral system with *Dichrostachys nutans* followed by Prosopis cineraria at existing stock of trees at farmers' field in arid climatic condition of Rajasthan. In a Hort-pastoral studies on sandy rain fed of Rajasthan, Sharma and Diwakar (1989) reported that *Cenchrus ciliaris* in association with *Zizyphus mauritiana* system produced 1.2 t/ha forage yield and did not affect the fruit yield. Similarly Vashishtha (1995) recorded an additional forage yield of 4.7, 12.9 and 32.9 g/ha in first second and third year, respectively of planting of *Cenchrus ciliaris* in inter roods of *Zizyphus rotundifolia.*

Leaf fodder production

Studies on lopping intensity (Bhimya *et al*, 1964) revealed that heavy intensity of lopping adversely affected the growth of *Khejri*. Further recurrent lopping reduced that leaf fodder yield irrespective of lopping perhaps due to successive reduction in the overall surface of new shoots. Need for a period of rest between two loppings of *Khejri* is, therefore, prima facie obvious for sustained yield of *loong* (leaf fodder of *Khejri*). It has been suggested that in arid area lopping of *Acacia spp*, particularly *A. nilotica* (ex. *A arabica*) should be regulated on a cycle of 4 years with restriction on lopping of thicker (diameter of 1.9 cm and above) branches. In Madhya Pradesh and Tamil Nadu lopping of Hardwickia spp was permissible only in times of scarcity.

Sharma and Gupta (1981) studied the effect of seasonal lopping on the top feed production and growth of *P. cineraria*. They observed that winter was the ideal season for lopping as it improved plant height and bole diameter of the tree as compared to trees lopped in rest three seasons i.e. spring, summer and monsoon. In similar studies on harvest of *Ziziphus nummularia* bushes in different seasons, the maximum top feed (*Pala*) 292 g/plant and shoot biomass 1170 g/plant was recorded in winter harvest as compared to other seasons (Saxena and Sharma, 1981). Fully grown (over 30 years of age) *P. cineraria* with well spread crown is reported (Muthana, 1980) to produce 25 kg air dried leaves, 5 kg pods, and 2 kg seeds in one year in 300 to 400 mm rainfall zone and a moderate sized plant (20 to 30) years age group) yields one kg seed. Complete lopping is reported (Kaul and Gyan Chand, 1977) to yield higher (58 to 72 kg/tree) than the lopping of the lower two third (28.48 kg/tree) and the lower one third (19.73 kg/tree) of the crown. There was no significant difference between two third and one third lopping treatments (Bhimaya *et al*,1964). Top feed production from *G. tenax* under wide and close spacing ranged from 0.03 to 0.11 t/ha from without pasture plots and 0.03 to 0.09 t/ha from pasture plots similarly top feed from *Z. nummularia* varied from 0.03 to 0.04 t/ha. There were not much variation in top feed yield from close and wider spacing plots (Sharma et al (1994).

Fuel yield in silvipastoral system

Afforested dunes in western Rajasthan produced 15 to 20 t/ha firewood in 200 to 300 mm rainfall zone (Bhimaya *et al* 1960). The firewood yield from *Prosopis juliflora* plantation was estimated at 15 t/ha at the end of 5 years (Kaul and Ganguli, 1964). Wide variations in yield with respect to the age and habitats of *P. juliflora* were noticed (Bhimaya *et al* 1967). Differences in the fuel yield between the habitats generally followed the pattern of rainfall i.e. increase towards the east.

Studies on fuel yield of *P. cineraria* revealed that for a diameter range of 12.4 to 25.7 cm the fuel yield ranged from 85 to 479 kg per tree with an average yield of 230 kg per tree of 20 cm mean collar diameter (Kaul and Jain, 1967). Kaul (1965) reported an average yield of 19 kg per tree firewood from *Calligonum polygonoides* at maturity (7 years old). Yield of 100 to 110 t/ha have been obtained from Casuarina equisetifolia raised in coastal Andhra Pradesh and managed under clear felling of plants with rotation age varying from 7 to 10 years (Rao, 1967). Away from the coastal area where water table and humidity were usually low, the yield varied from 25 to 65 t/ha (Ghosh, 1977).

It can be concluded from above discussion that over all biomass level of pastures, on- farm and other grazing lands could be enhanced by incorporating compatible species of trees, shrubs and grasses with proper management even under unfavorable climatic, edaphic and economic conditions in arid and semi-arid regions ultimately it will help in combating fodder crises during drought situations. This system also fulfill other requirements of farmers by increasing land productivity and resource use efficiency and help in minimizing soil and environmental hazard.

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ROLE OF REMOTE SENSING IN MAPPING GRAZING RESOURCES

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Remote sensing due to its synoptic and repetitive coverage helps in cost effective mapping of earth resources. Projects have been carried at national and regional level for mapping of wastelands in general and grasslands/grazing lands in particular. In last two decades number of sensors have been developed and deployed on satellites considering vegetation as a resource of prime importance. In Rajasthan, studies have been carried out for wasteland mapping and also on CPRs.

The repetitive nature of satellite coverage helps in mapping grazing lands in different season thereby not only mapping the their spatial distribution and extent but also their seasonal variations. In the context of semi-arid and arid region the season variation is very critical. This paper presents one such study which is carried out for studying dynamics of vegetation in Rajasthan which is largely dominated by grazing/grasslands in western Rajasthan. Studies are also carried out mapping of CPRs and would be presented.

Vegetation is a part of complex eco-system, which includes the plant cover, landforms and features of its surface deposits. In desert, a close relationship exists in a dynamic equilibrium among habitat, vegetation and its environment. Minor changes in the physical environment entail dynamic changes in vegetation. Vegetation differs in sequence of species and varies in sequence of time as well. The dynamic rhythm of vegetation varies in magnitude from extremely arid region of rainfall (100 to 150 mm) of western part of Jaisalmer to eastern part of Rajasthan (200 to 750 mm) and beyond. Blatter and Hallberg (1918-21) viewed that the vegetation types of western Rajasthan have been exclusively controlled by edaphic factors. Biswas & Rolla (1953) and Bharadwaj (1961) also classified desert vegetation taking edaphic factors into consideration.

Most of the area falls under arid climate and is characterized by sandy plains more or less barren of vegetation except in rainy season when multitudes of ephemerals come up and transforms the barren into green carpet. Ephemerals complete their life cycle before advent of summer heat and bulk of the area is once again transformed into open sandy plain, desolate and barren. In general vegetation in arid region is sparse. The bulk of vegetation consists of stunted, thorny shrubs and perennial herbs. In semi-arid region the vegetation mainly consists of grasses, interspersed with few desert shrubs. Depending upon rainwater and phenological events vegetation can be distinctly divided into EPHEMERAL, SEASONAL AND PERENNIAL.

Ephemeral vegetation, which constitutes the bulk of vegetation of the area, appear above ground just after first showers and complete their life cycle in incredibly short time. They die out as soon as soil gets dry. One of such pioneers in edaphic habitats is *Indigophera Cordifolia.*

Seasonal vegatation in arid Rajasthan are those, which complete their life cycle in one season. The life cycle of this kind of vegetation begins with advent of first shower of rain. Degeneration and mortality starts with the onset of early winter season. *Tribulus terrestris, Vernonia cinerea, Dicanthium annulatum* are predominant seasonal vegetation.

Perennial vegeatation are species which grow throughtout the year. Like seasonal vegetation, just after few showers of rainfall during the later part of June seedlings of these perennials, mainly grasses emerge from the ground. *Bothriclova pertusa* and *Cynodon dactylon* are the most common perennials.

The study of vegetation type, its extent & density, change dynamics gathers immense importance in light of decreasing green cover and increased awareness in the field of managing vegetation cover. Such studies become more relevant in the areas where vegetation is sparse and its conservation and preservation is of utmost importance.

The study has been carried out using IRS-1C WiFS data of three seasons – January, May & October.

- Objectives
    1. To assess the density of vegetation.
    2. Classification of vegetation by aggregation of three season data (January, May & October).
    3. Dynamics of vegetation density.Correlation of vegetation density with cumulative rainfall data

- Methodology
    1. Grid base preparation for the study area
    2. Geo-referencing of maps (1:250,000 scale) to the grid base
    3. Geo-referencing of three season WiFS data and digitization & mask preparation
    4. Vegetation Index (NDVI) of three seasons

Images obtained by space-borne imaging sensor integrate three components: a space component, atmospheric component and sensor component. Since, three season data has been used, it is required to normalize the data sets prior to the analysis. The digital numbers were converted to radiance values using band-wise saturation radiance and offsets and simple atmospheric corrections were performed by removal of Rayleigh path radiance. The NDVI has been generated, which shows strong near linear relationship to the fraction of visible radiation intercepted by vegetation canopy and appears to be almost insensitive to the variations in the canopy geometry. Each NDVI image was density sliced into five different classes viz. *Max. veg., Med. veg., Mod. veg, Less veg. And Barren/dry.*

o Classification of vegetation by aggregation

Density sliced images were recoded into two classes viz. vegetation and no vegetation. Aggregated output image was generated using lookup table depicting three vegetation types namely perennial, seasonal and ephemeral.

o Dynamics of vegetation density

Dynamics of vegetation has been studied by analyzing three season images using lookup table. Negative change indicates the downward trend in vegetation viz. from maximum to medium or from moderate to less etc. Positive change indicates the upward trend in vegetation viz. from less to medium or moderate to medium etc.

o Correlation of vegetation density with cumulative rainfall data

An attempt was made to correlate the vegetation development with rainfall using the NDVI of October season and rainfall data from June to September 1998. Rainfall data was collected from Central ground water board. The Cumulative rainfall was calculated district-wise from June to September as the NDVI image was of October 8, 1998 and considering that, the rainfall received till September might have had influence on vegetation development. Normalized mean NDVI was calculated for each district as a representative indicator of overall vegetation density.

- Density of Perennial vegetation
-

During winter season vegetation density in three major categories i.e. max, med and moderate is about 25.68 %. With the advent of summer heat the vegetation starts drying and it falls to 17.83 %. Major change is observed in maximum density from 6.84% to 0.14% and medium density from 8.7% to 2.43%. This change can be attributed mainly to harvesting of rabi crop. After few showers during monsoon season, once again perennial vegetation mainly grasses emerge and density increases to 29.93 %. This can be attributed mainly to kharif crop.

- **Density of Seasonal vegetation**

Seasonal vegetation are mostly dominant after mansoon season 17.87 % and during winter season 20.79%, whereas, during summer the density is almost insignificant 1.91%.

- **Dynamics of vegetation**

39.68% area exibit negative change from January to May season and positive change from May to October season. Majority of this area falls in eastern part of Rajasthan, some part in north & southern Rajasthan and majority of this area is under perennial vegetation. Decrease in density of vegetation is due to less rainfall between January to May, whereas, good rainfall during june to September results in vegetation development and hence indicates positive change.

22.94% area exibit no change from January to May season and positive change from May to October season. Majority of this area is under Seasonal or Ephemerals vegetation. Positive change is attributed to rainfall and subsequent vegetation development.

12.96% area exibit no change in both the season. This area is either predominantly sandy (in Western Rajasthan) or Rocky (in eastern Rajasthan)

- **Correlation of rainfall**

As evident, In general, normalized mean NDVI values shows increasing trend with higher rainfall. Districts – Jaisalmer, Barmer, Bikaner, Churu and Nagaur exhibit lesser increase because these are mainly under sandy plain and crop growing season is limited to moisture availability period, which is less than 80 days. The ephemeral vegetation, which emerges soon after the rainfall complete their lifecycle within short time and also the seasonal vegetation, which is very sparse in these districts and yield less NDVI values.

Districts namely, Jaipur, Dausa and Alwar although having no limitation of physiography and having intensive agriculture areas show less NDVI values. This can be attributed to harvesting of crops (by month of October). The crop residues and grasses left behind yield low NDVI values.

Conclusion

The study demonstrates the vegetation in Rajasthan is edaphically controlled. Though, large part is covered by perennial and seasonal vegetation, but their density is highly dependent on the availability of rainwater and subsequent soil moisture. The study also demonstrates that the satellite RS can be effectively used for mapping and monitoring of constantly changing phenomena like vegetation at regional level because of higher revisit and larger swath. The temporal-spectral behavior of vegetation, which is related to phenological and climatic factors could be easily studied using high repeativity. The studies carried out for mapping of common property resources also proves the potential of remote sensing technology for the purpose.

DROUGHT RESISTANT GRASSES AND WEED RESOURCES FOR FEEDING ANIMALS

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Arid region of India experiences extremes of temperature (0 to 4°C in winter and 45-48°C in summer), low annual precipitation ranging from 450 mm in the east to 100 mm in the west, low humidity, high wind velocity and high evapo-transpiration. Soils are sandy, poor in nutrient with low water holding capacity and prone to erosion by wind and water. Natural vegetation in such edapho climatic conditions is sparse and stunted, predominantly spiny belonging mainly to *Dichanthium-Cenchrus- Lasiurus* grass cover type and very small area having *Sehima- Dichanthium* type.

The vegetation in deserts is a unique blend of small trees, shrubs and perennial grasses. In fact, the perennial component of these systems forms the lifeline and sustains humans and livestock, particularly during drought or near drought situations. Nearly half of the reported 682 species in hot arid zone and India are ephemeral and seasonal, the majority being monsoonal. Monsoon herbage has immense potential not only as livestock feed but also as desert food for human beings. In fact out of 682 species, 331 are ephemerals belonging to 44 families. Some 52 species are winter ephemerals; 17 occur in both monsoon and winter. In true sense, some 262 species (38.70% of flora) constitute monsoon herbage. These belong to 184 genera and 44 families. Amongst families, Poaceae has maximum i.e. 50 monsoon species followed by 25 in Fabaceae and 20 each in *Cyperaceae* and *Asteraceae*, 15 in *Euphorbiaceae*, 13 in Convolvulaceae and 11 in *Acanthaceae*, and remaining families having lesser than these species. Some 60 species appear dominantly during monsoon. These occur on all land uses i.e. croplands and grazing lands. These seasonal species germinate with onset of rains and complete their lifecycle by setting seeds with decline in soil moisture. These grasses and weeds are an important feed resource for the livestock of desert where pastoralism is dominant system especially in lower rainfall areas.

Seasonals that appear to be out of place in croplands are called weeds. Desert farmers know the utility of these seasonal as valuable forage. Quite often, these seasonal are collected, air-dried and stored in livestock yard for future use. A study by the Institute to assess their biomass revealed that weed biomass often far exceeded their companion crop i.e. their biomass was 2 to 4 times more than crop. These are mostly palatable weeds giving 655 to 1564 kg/ha of dry matter depending upon preponderance of weeds. Thus seasonals as weeds contribute immensely to livestock feed.

Monsoon herbage act as rain-gauges i.e. some species will germinate only after a particular amount of rain is received in one event. In contrast, there are species, which germinate at the very first event of rainfall irrespective of amount. These include large number of species of *Indigofera, Aristida* and *Cenchrus.* If there is no successive rain within a span of 15-20 days these will start flowering and set seeds as early as 20 days to 40-50 days. It has been found that at each germination event, 20-25% seeds of entire seed bank germinate and remaining are dormant. This is an ecological adaptation in annuals to germinate only a fraction of total seed bank so as to preserve the rest for next rain event. This ensures that if seedlings die or disappear without completing life cycle and formation of seeds, the remaining seed bank portion held with in soil is able to regenerate and continue the progeny. If however, there are rains they continue to grow vegetative till they face water stress. Growth up to 50-60 cm height has been observed in these species in case of prolonged wet spell. This indicates the plasticity in annual habit of these plants.

There are a large number of studies on estimation of dry matter yield of monsoonals and it can be intend that monsoon seasonal not only make up 34% of floristic composition, they also make up over 50% of biomass of grazing lands which is palatable too, in both protection and degraded conditions.

Nearly 70% of grazing land in Indian arid zone are degraded while other are in 14% fair, 13% good and 2-3% have excellent class. It is these 70% areas which have poor perennial plant cover and hence a preponderance of monsoon seasonals in these makes available grazable material @ 500 kg/ha to sustain livestock.

The composition of seasonal undergoes a drastic change upon grazing. A comparison of protected and grazed paddocks of grazing land at the end of 3 years and receiving 150 mm, 250 mm and 400 mm rain at Chandan, Beechwal and Palsana respectively revealed that grazed sites had preponderance of unpalatable annual forbs and such grasses which have awns that deter animals from grazing. Different studies indicate that same species behaves differently in two different rainfall situations.

With increasing grazing pressure in arid areas perennial like *L. sindicus* showed earlier flowering, fruiting and seed set. Compressing the vegetative phase is thus a mechanism of evading grazing pressure in this perennial grass. All the annual species showed opposite trend. With increasing intensity of grazing, vegetative phase was prolonged and seed setting was delayed in *Aristida funiculate, Indigofera cordigolia, Indigofera linifolia* and *Corchorus tridense.* This shift in phenophase could be related to platability. After the monsoon rains, annuals were eaten in preference over the perennials. With continued preferred removal of annuals, these palatables will be first to disappear due to overgrazing. It means that such shift in phenophases, caused by increase in grazing intensity, can effectively be used as indicator of beginning of deterioration of rangeland health and desertification.

Monsoon herbage is important component of natural grazing lands, pastures and croplands. They are the only plants available even after the perennials are removed. Persistence to withstand pressures and re-appear once the favourable situations occur, make them highly resilient component of desert vegetation. Their life cycle strategy is also more suited to adverse temporal sequential stresses. Growth properly, they contribute up to 500-600 kg/ha dry matter in natural conditions. But there is a scope to capitalize its ecological properties to further increase its yield to double or treble by providing moisture just to flowering so that vegetative phase is prolonged.

In view of rich monsoon flora in our desert and the perennial vegetation persisting in the desert despite adverse climatic features, we are advantageously placed to use both annual and perennial grasses for livestock. At present the focus of research is mainly on perennial grasses like *Cenchrus cillirus, C. setigerus* and *Lasiurus sindicus.* Three varieties of pasture grasses have been developed at CAZRI, Jodhpur. The annual herbage is equally important and needs further study. Some of the perennial and annual grasses and pasture legumes commonly occurring in this area are as below:

Anjan: *Cenchrus cilliaris,* commonly known as dhaman in Rajasthan and anjan in various other parts of India, is a perennial grass with a stout root sock and is one of the dominant grass species in *Dichanthium-Cenchrus-Elynurus* complex of grass cover of India. It generally grows in warm, dry sub-tropical countries. It has been considered as a highly drought resistant grass species that can grow in wide range of soil and climatic conditions and can be cultivated in areas receiving ranfall from 150 to 1250 mm annually. The Institute has released variety CAZRI-75.

<u>Marwar Anjan (CAZRI-75) of *Cenchrus ciliaris*</u>: It is a tall (90-125 cm), erect, thick stemmed, leafy, drought hardy, with green yield potential of 70 q ha^{-1} $year^{-1}$ yielding 53 per cent higher over the check variety Molopo. It has high crude protein (8.3%) which is 32 per cent higher over the check.

Dhaman: *Cenchrus setigerus,* commonly known as moda dhaman in Rajasthan (in contrast to Ru-dar dhaman for *C. ciliaris*) due to absence of cilia on the spikes, is a perennial, forming clumps with somewhat bulbous base and grows up to height of 50 cm or so. A high yielding variety developed at the institute is described here.

Marwar Dhaman (CAZRI-76) of *Cenchrus setigerus* : It is a clonal selection from exotic material EC 17655. It is a medium tall (50-60 cm), thin stemmed, leafy (leaf-stem ratio, 2.3), foliage remains green upto December. It is drought hardy, high tillering ability (29 tillers plant^{-1}), fast regeneration (2-3 cuts in a year), average green fodder yield (40 q ha^{-1}) and 15 q dry matter yield which is 38 per cent higher over the check var. Pusa Yellow Anjan. It is also nutritious, having 9.6 per cent crude protein at 50 per cent flowering stage.

Sewan (*Lasirus sindicus* Henr.) The grass is confined to sandy to sandy loam habitat where the rainfall is less than 350 mm annually. Sewan is also called as the 'King of desert grasses' due to its drought resistant characteristics. It grows round the year except harsh temperatures, depending on moisture availability. It is a tufted perennial grass, 100 cm tall from a more or less oblique and woody, rhizomatous rootstock. Sewan is a common grass often forming extensive pasturelands for considerable area in western Rajasthan.

CAZRI-30-5 of *Lasiurus sindicus* : The variety was developed through mutation breeding by Yadav (1988). It yields 97 q green fodder and 33 q dry matter yield per hectare which is 38 per cent higher over the check var. Jaisalmer Local. It attains a height of 1 m. It is drought hardy, remains productive even in the regions receiving an annual rainfall of less than 100 mm, leafy (leaf-stem ratio 1.9 which is 46% higher over check). Its crude protein yield is 3.75 q ha^{-1} which is 63 per cent higher over check. Its pasture remains productive up to 15 years in the arid zone.

Gramna (*Paniaum antidotale* Retz.). It has a wider adaptability not exacting insoil/requirement. It is tall growing perennial grass, grows a height of 150-250 cm, has woody stem (on maturity) with a creeping rootstock giving off stolen and thickened modes. It is nutritive for livestock at flowering, grazed, used as art and carry method as well as hay.

Murtiogas (*Panicum tongidum* Forsk.). It is a grass of sand dunes and sandy plains in arid climate. A perennial, glabrous up to 1 m tall, roots fibres thick and felty. Excellent fodder particularly for camels.

Aristida plumosa: A dense tufted, perennial grass, up to 30 cm high. It grows in sandy soil and attains optimum growth during summer monsoon. It is a valuable fodder grass, and chief fodder for sheep.

Bhurat (*Cenchrus biflorus* Roxb.). This is a monsoonal tufted, glabrous annual grass species. Comes well in sandy soils. It is the most common grass used very much in fodder scarcity, grazed as well as cut and carry system.

Gharadhob (*Eleusine compressa* Forsk.). It is a prostate, profusely branched and widely spreading perennial. This is a grass of gravely and sandy soil. Optimum time for growth is summer monsoon. It is a fairly good fodder for cattle.

Pasture Legumes

Bekrio (*Indigofera Cardifolia* Heyne.). Bekrio is a browse species found in open rocky slopes/gravels. A prostate diffuse or sub erect, annual herb, usually clothed with long, white modifixed hairs. Stem up to 30 cm long. A very good legume fodder for cattle and goats. It is found throughout the country.

Goilia or Jhil (*Indigofera oblongifolia* Forsk.). It is found on open dry places. It is a perennial species, an erect ashy-grey, twinggy shrub, 60-130 cm high. This is also a browse species. Goats and sheep eat this legume fodder.

Butterfly pea (l *Citoria ternatea* Linn.). This perennial pasture legumes comes well in sandy to deep alluvial and heavy black soils. It is a twining perennial with a few foliage branches distributed through tropics and *subtropics. Stem fibrous or sparsely pubescent, terete. Dry matter production ranges from 20 to 40 q/ha.* Herbage contains 10 to 25% Crude protein. Grazed in pasturelands.

Low productivity of Indian livestock is a matter of concern, which is predominantly due to low quality and inadequate fodder and feed resources. Various natural and cultivated forages provide nearly 60% of the green fodder requirement of India's livestock. The challenge before us is to brig the gap between a demand of about 900 million tonnes and supply of 550 million tonnes.

PROPAGATION AND MANAGEMENT OF GRASSES OF ARID ZONE

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Perennial pasture grasses provide feed to the livestock as well as help in soil conservation and increase soil fertility. In their principal role as livestock feeds, grasses in the tropics stand as the highest yielder of starch and proteins being the dominant component of tropical pastures, as the cheapest source of animal feed. Development of pastures in the arid areas of Rajasthan may be a good proposition in amelioration of the economy of the farmers of this zone.

Rangeland and Pasture

The term 'range' refers to a vast areas supporting natural vegetation, which is suitable for grazing and browsing by livestock. These lands are generally not suitable for cropping due to some soil limitations and moisture deficiency. Most of these lands are marginal and are in seriously degraded conditions on account of over exploitation.

Distinct from rangelands, "Pastures" are usually fenced and comprise relatively smaller areas of the better lands (land use class IV and lower). These pasture lands compete directly with cropping lands, where rainfall is higher than 350 mm annually.

Important pasture grasses of arid zone

Sewan (*Lasiurus sindicus* Henr.): It is popularly known as 'sewan', one of the dominant species of *Dichanthium-Cenchrus–Lasiurus* type grass cover of India. It survives under extreme arid conditions of Rajasthan and gives high forage yield. The grass is extremely drought resistant and thrives even in very low rainfall regions receiving 100 mm to 300 mm annually and has moderate tolerance to salinity. This grass naturally grows on extensive areas in far west of Rajasthan desert. The grass comes well in sandy soils. It is highly nutritive and palatable to the livestock. Tharparkar breed of cattle of western Rajasthan is dependent on this grass. Under natural conditions crude protein (CP) ranges from 5.9 to 6.7 per cent but when cultivated and fertilised with NPK, CP can reach up to 15 per cent. Three hectare of *L. sindicus* is sufficient to support one adult animal (cattle) throughout the year. From good condition grasslands 150 to 250 q green fodder and 50 to 75 q dry matter can be harvested from one ha. Seed production depends on various factors and ranges from 5 to 40 kg ha^{-1}.

Buffel grass (*Cenchrus ciliaris* L.): Commonly known as 'dhaman' in Rajasthan and 'anjan' in other parts of India, is considered as a very drought resistant species. It is adapted to a wide range of soil and climatic conditions and can be cultivated in areas receiving rainfall from 150 to 1250 mm annually. The grass has been successfully established on dry sandy to stony soils in arid and sandy-to-sandy loam in semi-arid parts of India. It can also grow on deep basaltic soils and on red lateritic soils. It is very palatable when young, and remains fairly palatable at maturity. It is one of the best forage grasses for semi-arid areas in the sub-tropics and tropics. Crude protein percent varies from 6 to 10. The varieties like Marwar Anjan, Bundel Anjan, CAZRI 358, Biloela and Molopo give 40 to 45 q ha^{-1} dry matter. Depending on the soil moisture 3 to 4 cuts can be obtained from August to April. Seed productivity is 10-60 kg ha^{-1}.

Bird Wood Grass (*Cenchrus setigerus* Vahl): It is commonly known as 'moda dhaman' in Rajasthan and bird wood grass in USA. It is extremely tolerant to heat and drought and will grow in areas of annual rainfall as low as 200 mm making it excellent for improvement of low rainfall grazing lands. It does not respond to winter rain. It is palatable to all kinds of livestock and can be propagated from seeds and may be used for renovating the denuded pastures or establishment of sown pasture. The grass is either grazed or cut and fed to livestock *ed lib* or turned into hay. Crude protein content of dry matter varies from 5 to 12%. High yielding varieties of *C. setigerus* produce about 40 to 50 t ha^{-1} of green forage from 2 to 3 cutting during August to April in arid regions. The yield becomes double in semi-arid regions. The dry matter varies from 4 to 20 q ha^{1}.

Karad (*Dichanthium annulatum* (Forsk) Stapf): It is commonly known as 'karad' in Rajasthan and Marval, Palwan and Zinjoo elsewhere. In Rajasthan it occurs mainly in the rainfall regions of ≥ 350 mm. It evades or endures drought well (White, 1968). The plant grows to a height of 75 cm at maturity stage. It is regarded as an excellent fodder plant and highly valued pasture of high quality, vigour and productivity. An average hay production of 33-q ha^{-1} can be expected from a good *D. annulatum* stand (Dabdaghao and Shankarnarayan, 1973).

Blue Panic (*Panicum antidotale* Retz.): Blue panic popularly known as 'gramna' in Rajasthan. It is often found on sand dunes and excellent sand binder and drought resistant perennial grass adapted to a variety of soils and climatic conditions. It is a very productive grass that can serve as a good source of fodder supply either as hay or silage. On the livestock farms of the tropical and sub-tropical countries this can be a good fodder source through out the year because of its wider adaptability, persistency, high productivity and good seeding capacity. It can be either grazed or cut and fed to the livestock. It shows that the grass is highly nutritive when cut at pre flowering stage. The grass is palatable to all kinds of livestock. However, it is not liked in mature stage as the stem becomes hard and woody.

Murat (*Panicum turgidum* Forsk.): Grown on sand dunes and sandy plains in open rangelands and cultivated fields of Thar Desert of Rajasthan and Gujarat. A common and characteristic species, often playing an important role in colonizing shifting sand dunes under 100-250 mm annual rainfall. Green fodder productivity ranges from 50 to 75-q ha^{-1} with 20 to 30 q ha^{-1} dry matter. Although hard and woody, young stems serve as an excellent nutritive camel fodder. It has 59 per cent dry matter at flowering and CP 4.9 %.

Pasture establishment and improvement

Routine pasture improvement practices as applied under higher and more reliable rainfall conditions are out of question in the arid and semi-arid regions in northwestern India. Climatic conditions in these areas are too erratic and individual falls of rain are too ineffective for regular germination and continued early growth of introduced species. Introduction of new species is risky in the areas below 300 mm average annual rainfall. While selecting the species priority should be given to indigenous species. Following are the techniques, which may be helpful in getting higher production from pasturelands.

Fencing: Fencing of the area is essential to minimize the loss owing to overgrazing in pastureland. Angle iron posts with barbed wire are the most effective fencing but the initial cost is high. Hence, ditch and core wall fencing may be constructed through 'sharmdan' or participatory approach. To feed species like *Acacia senegal, A. tortilis, A. nilotica* var. *cuprisiformis, Calligonum polygonoides, Capparis deciduas,* etc can be planted on the core wall.

Choice of species: For the less than 300 mm rainfall zone in deep sandy soils *L. sindicus* is the only choice. On sandy loam soils *Cenchrus* species are recommended. Above the 300 mm rainfall zone *C. ciliaris, C. setigerus, Panicum antidotale* and *P. turgidum* grasses are recommended. In heavier soils of the higher rainfall zone, *Dichanthium annulatum* and *Cenchrus* species are recommended.

Land preparation

***On plain sites*:** Complete land preparation and sowing in rows at a distance of approximately 75 cm in less than 300 mm rainfall zone. The distance between rows should be 50 cm in areas of above 300 mm rainfall.

***On slopping sites*:** In areas of above 3% slopes contour furrows and bunds are recommended. On still steeper slopes closer distance of furrows should be adopted.

Propagation of grasses

1. **Sowing method**: The sowing can be done by the following methods.
2. *Direct seeding*: Seeds of pasture grasses are light and remain stuck to each other resulting in uneven distribution of seed and higher seed requirement. Therefore, the seeds are mixed with wet field soil in 1:5 ratio (by volume). This seed is drilled in open furrows after effective showers of monsoon. Line sowing is preferred as it makes the after sowing operations easy.
3. *Transplanting method*: Rooted slips/newly raised seedlings are planted at the onset of monsoon. Two to three seedlings are placed in a hill. For better establishment water is must at the time of plantation. After planting 2-3 watering is also required.
4. *Pelleted seed sowing*: Pastures are generally established through direct seeding or transplanting. Some practical problems are faced with direct seeding in general and for undulated areas in particular and transplanting being labour oriented becomes a costly affair. Hence, pelleted seed sowing may be an alternative for undulated terrain. Pellets are prepared with 100-125 g grass seed, 3-3.5 kg clay soil, 250g sand and 250g FYM. For one hectare 60-80 kg pellets are required.

Sowing depth and spacing: The caryopsis in seeds of grasses is small and should not be sown deep otherwise seedlings will fail to emerge at the surface. Seeds of the desert grasses have shown optimum germination under field conditions when sown at shallow depth of 1-2 cm with a light soil cover.

Cenchrus ciliaris, C. setigerus and *D. annulatum* with 50-75 cm row-to-row spacing proved to be the best for optimum forage production in arid zone. *L. sindicus, P. antidotale* and *P. turgidum* exhibit more radial expansion. The row-to-row spacing for these grasses vary from 75 to 100 cm depending upon soil types and rainfall conditions.

Sowing time and seed rate: The time of sowing is limited to period in which soil moisture and temperature are sufficient high to permit rapid germination and establishment. All the above-mentioned grasses may be sown after first effective showers of monsoon (last week of June to July).

The seed rate for grasses vary considerably, however the seed requirement for one hectare is 6 kg for *L. sindicus*, 5 kg for *C. ciliaris* and *C. setigerus*, 2-3 kg for *D. annulatum, P. antidotale* and *P. turgidum*.

Pasture Utilization: Scientific utilization enhances the productivity and longevity of the pastureland. Pasture can be utilized by following methods-

Cut and carry method: Cutting at right stage is must. In a normal rainfall year two to three cut can be taken if cut at 50% flowering. It is essential to protect pasture in the year of establishment from grazing by animals. In the establishment year the fodder from the pasture may be harvested and conserved as hay for utilization in lean period. Higher production of pasture starts from the second year onward, hence utilization of pasture in rational way is advocated for effective maintenance of regeneration in subsequent years.

Grazing: To harness the maximum productivity of pasturelands, controlled grazing based on carrying capacity is the best way. Suitable grazing system also enhances the longevity of the grasses.

Hay making: Excess fodder of good rainfall year can be converted into 'hay' for scarce years. Fodder banks may be created at least at Panchayat Samity level.

Production: Production of pasturelands depends on climate, soil type and management. The average dry matter productivity of *C. ciliaris, C. setigerus* and *L. sindicus* is 30-35, 20-25 and 35-40 q/hectare, respectively. The peak forage production from the pastures of Cenchrus species can be seen in 3rd and 4th year and starts declining after 5th year. Rejuvenation of pastures hence needs to be undertaken after 5 or 6 years. *Lasiurus sindicus* pasture lasts for decades.

Maintenance of pastureland

Sowing of grasses in the abandoned and weed infested area often leads to failure of pasture establishment. Removal of weeds before seeding and subsequent weeding after sowing of grass seed would ensure better establishment of pasture and forage production. Two weeding at an interval of 3 and 7 weeks after germination are required during the year of pasture establishment. Inter culture operations by tractor drawn cultivator are required for better aeration. This provides favourable environment for root development ultimately resulting in increased productivity of pastures. Overgrazing invites annual grasses hence grazing should be as per carrying capacity of the pasture by following any scientific method. Pastures should be well protected from stray animals. If utilized through cut and carry system cutting should be at right stage. The remnant portion of grasses should also be removed before the start of dormant period. Reseeding should be done when the productivity start declining.

Prospects of pasture development in arid zone

The economy of the farmers of Thar Desert is based on animal husbandry. Pasture grasses are the common source of roughage to cattle. Improved pasturelands can provide 15 times higher fodder over the existing ones and become a good source of income round the year. During droughts, when the crops fail, these grasses remain productive and provide fodder if only few showers are there. Improved pasture also provided employment to the rural people through out the year, i.e. selling the dairy products and forage in nearby areas, cities and other areas. The seed production of gasses may also be a beneficial enterprise.

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IMPORTANCE OF RUMEN MANIPULATIONS TOWARDS IMPROVING PRODUCTION EFFICIENCY OF ANIMALS IN DROUGHT SITUATION

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Certain parts of India (e.g. Gujrat, Rajasthan, MP and Orissa) faces drought like situation quite frequently due to failure of monsoon. Livestock contribute more than 50% of the GDP in the drought prone areas. The immediate impact of prolonged failure of rain is on the health of the livestock, due to lack of feed, fodder and drinking water; and leads to high livestock mortality and morbidity which has widespread ramification on poor farmer's economical condition. Saving animal wealth under such situation is utmost important as it constitute backbone of the livelihood security system poor farmers of the country. Across the semi-arid regions of the world, that natural pasture is dry and of little nutritive value for many months of the year. Many ruminants kept by small farmers on the drought prone areas feed on nothing but unimproved pastures and edible parts of shrubs and trees throughout their lives. In the dry season proper, when the standing grass is mature and dormant, the grazing comprises mostly hard-to-digest fibre with low protein content. In periods of drought, even this material is in short supply. There is huge potential for improvement in animal production in drought affected areas via manipulating the ruminal fermentation using well established principles of rumen microbial ecology and understanding dynamics of substrate fermentation.

Manipulation of rumen fermentations can be considered as an optimization process, whereby optimal conditions are sought by maximization and/or minimization of fermentation processes, depending on factors such as kind and level of feeding and animal production. Most of the available technologies on rumen manipulation are related to grain fed high producing animals as the developed nations are more concerned with grain based feeding system and not with scarcity feeding or poor quality fibrous feeds. Rumen manipulations for high producing animals fed grain-based diet will not be discussed here. Rumen manipulations aimed at maximization of crude fibre degradation, microbial protein synthesis, maximization of degradation of antinutritional factors and minimization of methane production in poor quality fibrous diet will be dealt in ensuing sections.

Altering the composition of ration and feeding method, or processing ration components

Digestion in the rumen is dependent on the activity of the micro-organisms, which need energy, nitrogen (ammonia, peptides, amino acids), minerals. Poor quality roughages have insufficient nitrogen, sugar, starch and mineral content to satisfy microbial needs and therefore these needs to be supplied to optimize cell wall degradation. Salter and Slyter (1974) advocated a minimum value of 5 mg ammonia-N per 100 ml rumen fluid for optimum microbial growth. Durand (1989) recommended a total N requirements of 26 g N/kg OMAD (apparently digestible organic matter) in the total digestive tract. Traditionally low N diets are supplemented with urea to supply N for optimal microbial growth. It has been suggested that microbial growth will be stimulated by adding extra amino acids, peptides and proteins in diets (in form of oil cakes or fish meal) where supply of amino acid N is low (Wallace, 1991). Studies have indicated that digestion of untreated straw is increased by 9-15% when some source of digestible cellulose, hemicellulose or starch supplements (e.g. alkali or ammonia treated straw, grass, fodder, legume fodder or leaves or pods of leguminous trees, legume straw, beet pulp, molasses or starch rich concentrates) are supplemented in small amounts(Juul-Nielsen, 1981; Silva and Ørskov, 1988; Zorrila-Rios *et al.*, 1989). The leaves and fruit of indigenous fodder trees can be used to supplement pasture grazed in the dry season. However, many trees and plants protect themselves against stresses such as drought, insect predators and microbial infections by producing toxic compounds that adversely effect the host animal on their ingestion or the micro-organisms of its rumen. Several deleterious compounds have been identified in forages and fodder trees. Fodder trees, shrubs and other plant material must therefore be examined for such anti-nutritional factors before their use as feed supplements can be recommended.

Certain minerals are limiting in metabolism of rumen microbes in straw based diets which need to be supplemented. The suggested rate of inclusion is 1.8 g sulpher/kg OMD, 5 g phosphorus/kg OMD, 1.5-2.5 g magnesium/kg OMD and 0.5-1.0 mg cobalt/kg DM (Komisarczuk-Bony and Durand, 1991).

Mechanical and chemical or biological processing of feeds like chopping, grinding, pelleting, urea or alkali treatment, treatment with white rot fungus, etc . increase digestibility and reduce loss of energy in form of methane from fibrous diets (Wieser and Wenk, 1970; Walli *et al.*, 1987; Sundstøl, 1988; Moss *et al.*, 1993).

Increasing feeding frequency and feeding complete diet (concentrate and roughage together as total mixed ration) also improve rumen environment and digestibility and performance of animals.

Use of probiotics

Some aerobic viable yeasts or fungi (*Saccharomyces* or *Aspergillus* spp.) added in very small amounts stimulate growth of cellulolytic bacteria in rumen by improving rumen condition (pH, anaerobiosis) or by the supply of bacterial growth factors (Dawson et al., 1990). However, response to probiotics in animals are inconsistent and depend on strain and feeding condition and increase in animal performance is only 7-10% (Wallace and Newbold, 1993). The effects of probiotics on methane production has not been studied carefully. Frumholtz *et al.* (1989) found that ruminal protozoal numbers were reduced 45% by treatment with the probiotic. As methanegenic bacteria have been found to be associated with ruminal protozoa , some decrease in methane may have been due to this decrease in protozoan numbers.

Use of enzymes

Earlier it was believed that rumen microbes produce sufficient enzymes and that exogenous enzymes cannot remain active in rumen because of high proteolytic activity. Now it is established that microbial enzymes produced in rumen are insufficient or limiting and exogenous enzymes are quite stable in rumen. Supplementation of fibrolytic enzymes in diet of ruminants fed poor quality fibrous diet has consistently improved digestibility of feed and performance in ruminants and are being used widely (Yang et al., 1999).

Direct manipulation of rumen microbial population

Rumen fermentation can be manipulated directly by altering microbial population through use of chemicals to selectively stimulate, suppress or eliminate particular group of microbes and by introducing digestion-enhancing bacterial or fungal species or specific toxin degrading microbial species from other animals.

a) Methane inhibitors/propionate enhancers and herbal additives

Many chemical compounds e.g. monensin or other ionophores (Moss, 1993), bromochloromethane (Haque and Bhar, 2001) have been found to be effective as additives for ruminants which reduce methane production and increase propionate production. But their cost, availability, potential risk of residues in milk and meat and microbial adaptation in long use restrict their use in practical roughage based diets. Plant extracts (e.g. *Kutaki picorrhiza*) containing plant secondary metabolites such as essential oils,sarsaponins, phenolics, etc. have been shown to reduce methane production, reduce rumen ammonia production, suppress protozoa and increase feed efficiency by stimulating growth of favourable microbes (Ando *et al.*, 2003;Wadhwa and Bakshi, 2006).

b) Defaunation

Removal of rumen protozoa has been shown to be beneficial for animals fed fibrous diets as protozoa contribute to nitrogen inefficiency in rumen because they engulf bacteria, passed out at a slower rate and undergoes lysis in the rumen thus reduces availability of protein to animals (Kamra *et al.*, 2000; Gregorio *et al.*, 2005). Digestibilty of nutrients increases and better growth rate and wool production has been reported in defaunated animals. In some studies lower rumen ammonia level, lower methane production and higher VFA production has also been reported. This is probably because of increased fungal and bacterial growth and reduction of methanogens in absence of protozoa. Different method of defaunation like chemical treatment (e.g. sodium lauryl sulphate), grain feeding and feeding of saponins are employed for defaunation but maintaining animals in defaunated state is difficult and chemical defaunating agents are toxic to animals.

c) Transinoculation

The fastest way to improve rumen function in an animal is to introduce digestion-enhancing bacterial/fungal species from other animals or to selectively increase populations of species that inhabit the rumen only at low levels. The rumen microbial ecosystem is an extremely diverse and competitive environment. Because of this, many researchers were initially skeptical of being able to administer a DFM (direct fed microbial additive) that would have lasting effects in the rumen. Bacteria and fungus from one ruminant species have been experimentally shown to colonize others successfully. There have been several documented cases of improved animal performance when the rumen has been inoculated with selected microbes. For example, the toxicity of mimosine present in the tropical forage *Leucaena leucocephala* and its degradation products 3,4 DHP and 2,3 DHP (goitrogens) in unadapted animals could be prevented by inoculation of specific bacteria *S. jonesii* isolated from adapted animals or rumen liquorfrom adapted animals (Jones and Megarrity ,1986; Allison et al., 1990; Paul et al., 1998). Another example of a successful application for a DFM is in the case of monofluroacetate poisoning in Australia. This compound is found in some Australian plants and can be toxic to ruminants at doses of about 0.3 mg/kg of body weight. Gregg *et al.* (1998) reported that they successfully inserted the gene encoding for fluoroacetate dehalogenase into several strains of *Butyrivibrio fibrisolvens.* When sheep were inoculated with the altered microbes, they showed reduced toxicological symptoms. The detoxification of 3-hydroxy-4 (1H)-pyridone and monoflouroacetate are good evidence that ruminal fermentation can be modified with lasting effects by a DFM.

Administration of an elite anaerobic fungus, isolated from goats, to sheep resulted in increased digestibility and intake of lingocellulosic feeds (Lee et al., 2000). Similarly Paul et al (2004 a,b) reported that dosing of buffaloes with a non-indigenous anaerobic fungi (Piromyces sp. FNG5 isolated from faeces of wild blue bull) having higher cellulolytic activities than those isolated from buffaloes, goat, sheep, spotted deer, black buck and hog deer resulted in several fold (2.5-4.4 times) increase in cellulolytic microbial population and increase in digestibility of fibre/cell wall components (NDF digestibility increased by 15.7% and ADF digestibility increased by 17.7%) and 58% increase in VFA production. Tripathi *et al* (2006) also observed that a superior fungal isolate from wild blue bull when dosed into rumen of buffalo calves increased growth rate and feed efficiency in buffalo calves by 30%. and tannic rich tree leaves (Paul et al., 2006). Gordon *et. al.* (2000) reported that dosing of sheep with nonindigenous anaerobic fungi (*Piromyces* sp. CS15 isolated from cattle rumen) having higher cellulolytic activities than those normally isolated from sheep resulted in 12 percentage point increase in voluntary dry matter intake. It was observed that three of the six sheep dosed with strain CS15 contained the fungus at 2 months post dosing.

It has been further demonstrated that the cross-inoculation of rumen fluid or microbes from wild to domestic ruminants alleviates tannin toxicity and enhances the productivity of livestock browsing tannin-containing shrubs (Brooker et al., 1994). In an earlier study undertaken by us indicated that an anaerobic fungal isolate obtained from wild blue bull had high tolerance to phenolic monomers and also degrade phenolic monomers (Paul *et al.*, 2003). Such a fungi when introduced into rumen microflora of buffalo increased degradation of hydrolysable as well as condensed tannin (Paul *et al.*, 2006).

d) Introduction of genetically engineered microbes

Rumen ecology may also be modified by altering the function of bacteria using genetic engineering techniques. In the past ten years, many approaches have been taken in attempts to transform rumen bacteria by introducing a foreign gene or genes into the bacteria. Research in sheep conducted at the Institute of Biology and the Institute of Biotechnology, *University of New England*, both in Armidale, Australia (Gregg *et al.*, 1998), has proved that genetic manipulation of rumen bacteria is feasible. Bacteria grown in the laboratory were shown to recolonize the rumen and genetically modified bacteria did so as efficiently as their unmodified counterparts. The altered bacteria neither died out, as some scientists suspected they would, nor affected the health of the sheep. In future use of recombinant rumen microbes may become practical highly useful and safe in developing countries.

Future research needs

Integration of research findings for rumen manipulation for practical application has the potential to improve survival and performance of animals under drought and scarcity considerably. More basic research need to be undertaken for understanding molecular basis for variation in ability in degrading lignocellulose or plant toxcants among microbes of different habitat which will be helpful in developing superior genetically modified or naturally selected superior strains of microbes for more effective rumen manipulation. Future of extensive rumen manipulation lies with success in development of genetically engineered designer microbes or plants, which need extensive research in this direction.

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MULTIPURPOSE TREES AS ALTERNATE FEED RESOURCES FOR BETTER LIVESTOCK PRODUCTION IN DRY AREAS PARTICULARLY IN ARID ZONE

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Introduction

Tree based farming systems or agroforestry is an age old practice. In the recent past agroforestry has been recognized as a land-use system, which is capable of yielding both wood and food, and at the same time conserving and rehabilitating the ecosystem. Agroforestry has the capability to increase the productivity and at the same time maintain the nutrient balance as well as protect the nature. Hence trees in agriculture plays important role in sustainable agriculture as well as environmental protection.

However, in arid regions of India growing of trees in agricultural fields or in the pasture lands has a great role because due to frequent drought, agricultural crops failed and trees acts as crop insurance. During the drought period, trees provide leaf fodder for livestock, beside leaf fodder; they provide fuel wood, fence materials, fruits, gum etc. Even some times, farmers cut the trees and by sale of them, they earn the money for their livelihood. Therefore, in the twelve arid district of Rajasthan, animal farming becomes a major occupation. In India animal husbandry contributes about 32% of total agricultural revenue, which is 27% of GDP where is in Rajasthan State it contribute 19% of the GDP. During the drought period, farmers lopped the trees and fed to their animals during the lean period and save their animals. Similarly farmers maintained trees in their orans/grazing lands for the providing feed to animals during lean period. During the monsoon, the in orans/grass lands, good quality of grasses available having 10-12% crude protein but as the monsoon reseed, the grasses dry and their crude protein fall to 4-5% which is not sufficient to maintain the animal health. Therefore, if green leaves/pods mixed with dry grasses, than total CP value of feed can be increased and sufficient to maintain the animal health.

Feed &fodder scenario

The fodder production vary widely depends on the cropping pattern, socio-economic conditions, and type of livestock. The cattle and buffaloes are normally fed on the fodder available from cultivated areas, supplemented to a small extent by harvest-harvested grasses and top feeds. The three sources of fodder supply are crop residues, cultivated fodder and fodder from common properly resources, viz. forests, permanent pasture and grazing lands. The deficiency in field and fodder is identified as one of the major constraints in achieving desired level of livestock productivity. The shortage in dry fodder, green fodder and concentrates are 21.8, 61.5 and 47.1% compared with the requirements of 560,1006 and 79.4 million tones for current livestock population (2003) respectively. (***Bhagmal*** *et al*, 2006). However, the fodder availability scenario is ever worst in arid region. In the arid region there is a perennial shortage of 28 million tons/yr green fodders, which is 40% of the gross production. This may rise to 80-90 % during extreme drought years requiring large volume of import of fodder from neighboring state.

Therefore, to bridge the gap between demands and supply if top feed species introduced than they can contribute 6 to 66% fodder to the system. Hence introduction of top feed species can bridge the fodder requirement as well protein requirements.

Fodder tree species

In arid region about 277 species reported (Bhandari 1999) of which 51 species of 34 genera belonging to 20 families are trees/shrubs and have multipurpose uses (Table –1). Among them few are very commonly used).

As mentioned in Table 1, if these trees are properly explored/optimally utilized for different purposes, then whole economy of western Rajasthan can be changed and economy of poor people can be changed.

The tree component is included in agroforestry system since ageses to get tree fodder especially during lean period in arid and semi-arid regions. Besides leaf fodder some other tree products are also used as a component of feed formulations and many of these are not properly evaluated. Since ages people of the regions have screened the trees which have multiple uses and did not have any adverse effects on the companion crops/grasses and also doe s not have adverse effect on the human and animal health. The leaves, pods, fruits are being used as animal feed during lean period (summer) when under story grasses dried and their nutritive value declined and are not suitable to maintain the animal health. Therefore, if tree products are mixed with the grasses/crop Stover than their nutritive value can be increased.

Table 1. Multipurpose trees and their uses.

	Name of Tree/shrub		Uses
1	*Prosopis cineraria*	:	Leaf as fodder, green pods as vegetable, Dry pods as fruit, lops & tops as fuel, wood as minor timber and fuel, shed tree, nitrogen fixing tree
2	*Acacia senegal*	:	Leaf fodder, seeds as vegetable, wood as fuel, gum
3	*Capparis deciduas*	:	Green fruits as vegetable ripened fruits as fruit, Wood for making keel for floor chaki
4	*Tecomella undulata*	:	Wood for furniture
5	*Calligonum polygonoides*	:	Root as fuel wood, flower buds for vegetable, Green branches for camel fodder
6	*Salvadora oleoides*	:	Leaves as cattle feed, fruits for human consumption. Seeds for nonedible oil and cake for animals.
7	*Ziziphus nummularia*	:	Leaves as food, ripened fruits for human consumption, thorns for fencing
8	*Z. rotundifolia*	:	Leaves as food, fruits for human consumption, round wood as poles, thorns for fencing
9	*Ailanthus excelsa*	:	Leaves as fodder, wood for ply industries.
10.	*A. jaquimontii*	:	Twigs for making baskets, small quantity of gum, soil conservation etc.
11	*A. tortilis (Exotic)*	:	Used for sand dune stabilization, leaves and pods for livestock feed, gum, wood for furniture
12	*Prosopis juliflora(Exotic)*	:	Wood Used for charcoal making, pods as livestock feed, used for sand dune stabilization and reclamation of saline-sodic soils.

Fodder production and carrying capacity in silvi-pastoral systems : It revealed from the table -2 that the reseeded pasture can maintain one ACU for approximately 310 days and if multipurpose trees grown along with the grasses than carrying capacity can be increased from 310 days to 344 days and 780 days in rainfed and irrigated areas respectively except in Bordi-pasture land which can maintain one ACU for 231 to 257 days. In irrigated areas stovers of bajra and wheat can maintain one ACU for 450 days and if *Ailanthus excelsa* planted on the farm boundaries (80 trees) than one ACU can be maintained for 780 days. Thus it revealed that introduction of perennials can increase the carrying capacity of land. Harsh *et al* (1992) also reported that carrying capacity of sheep can be increased from 3.9 to 4.1 sheep/ha/yr in silvi-pastoral system (*Cenchrus ciliaris+ Hardwickia binata, Colophospermum mopane*)

Protein Production in Silvi-pastoral Systems: As the rainfall reseeds from September onwards, the grass protein values also declined. At the pre- flowering stage, the protein value of grasses are very height (12%) but once it dried it declined to 4% and which is not able to main the animals. But in the Silvi- pastoral systems tree leaves provides high protein ranged between 12-16%.Therefore, based on the protein requirement (1gm/1kg/of animal) , it revealed that reseeded pasture can maintain one ACU for 333 days whereas silvi- pastoral can maintain one ACU for 567 days. In irrigated area this value can go upto 760 days (Table 2) the availability of crude Protein to animals are higher when calculated on protein basis than total biomass production. In ardu based agroforestry system it was 1780 days/ACU. Whereas on protein basis it will be 1760 days for one ACU.

Agroforestry Systems : Institute has developed many agroforestry systems and few of them described as under.
***Acacia senegal*:** *A. senegal* grows widely in Western Rajasthan. It grows on sand dunes, sandy plains and rocky sites (Magra). Its density ranged between 10-30 trees/ha. Few trees are very old (>50 years). Local people collect the dry pods and extract the seed, which used for vegetable. Its seeds are one of the important components of Punch-Kuta. The seed production ranged between 1-5 kg/tree and sold in the market @ Rs. 20/- per kg. Hence it is not much economical. If this plant used for gum tapping as it has been practicing in Sudan and their economy depends on the gum export. Sudan contribute 80% of total gum export, whereas the same plants hardly produces 10-100 gm gum/tree in India. Therefore, in India gum-tapping techniques is to be developed for optimum gum production Khan & Harsh (1992) developed gum-tapping technique and by that technology on an average 500 gm gum/tree can be harvested. If 30 trees maintained at the farmland and used for gum tapping after 10 years of plantation than 20 kg/ha/yr gums can be harvested. If gum solid @ Rs. 200/- per kg than Rs. 2000/- can be earned. Farmers can additionally earn Rs. 2000/ha/year till the plants attained 20-25 years of age. Otherwise farmer was earning only Rs. 300/- to 600/ha/year by sale of *A. senegal* seeds.

Under its canopy or in between the tree rows, farmers grow the crops as well as grasses. The tree leaves are palatable and browsed by Goat, Camel and Sheep. In Sudan also, farmers allows their animals to graze in the gum gardens before and after harvest of Gum from *A. senegal*.
Acacia tortilis : *Acacia tortilis* an exotic was introduced in India from Israel in early sixties and because of its fast growth and well adopted to arid regions it was planted on roadsides, sandy plains and sand dunes. On the sand dunes it grown very fast and able to check the sand erosion. Therefore, it was found to be one of the most suitable species for sand dune stabilization. It is very fast growing and yield 53 t/ha at the age of 15 years when planted at the spacing of 3 X 3 m. (Muthana and Arora 1980).

Besides, sand dune stabilization, it can be grown with the grasses i.e. in Silvi-pastoral systems. Muthana et al (1985) reported that growing of *Acacia tortilis* along with *Cenchrus ciliaris* was more economical than growing grasses alone (Table 3) . Besides gum production, clear bole can be used as timber in handicraft industries. Harsh (2006) reported that on an average 2 CFT wood can be harvested at the age of 15 years. If wood sold @ Rs. 200 per CFT than Rs. 60,000/- ha can be earned keeping 100 trees/ha (Table 4) It revealed from the table-3 that cultivation of pure grass gives the return of Rs. 15,000/- per ha whereas growing *Cenchrus ciliaris* with *A. tortilis* return will be of Rs. 85,200/- per hectare.

***Salvadora oleoides* based silvi-pastoral system:** In the flood plains of the arid and semi-arid regions *Salvadora oleoides* is a common trees associated with grasses as well as crops. The density ranted between 10-30 trees/ha. In the oran lands in between the interspaces grasses are growing. Not only it grows in the orans/grassing lands, it also grows in the farmer's fields. *Salvadora oleoides* does not have any negative effect on the crops as well as on the grasses, hardly, 10% reduction in crop was reported (Harsh et al 2005).

The leaves are browsed by the Camel and Goat. The fruits are edible. The fruit production ranged between 30-80 kg/plant, but hardly 10% of produce used while rest of the fruit production perish. From the seeds about 50% non-edible oil can be extracted. Since its fruits are edible and to utilize its produce maximum, Harsh *et al* (2005), Khan *et al* (2004) developed the technologies for preparation of squash and Jam from the *Salvadora* *oleoides* fruits. Harsh et al (2005) reported that about Rs. 2400/- per ha steer can be earned more when *S. oleoides* grown with bajra (pearl millet) and if its fruit processed for squash and jam than Rs. 8574/- can be earned more than mono-cropping of bajra (Table 5)

***Ziziphus nummularia* based pasturelands**: Growing of *Z. nummularia* and *Z. rotundifolia* with agricultural crops/grasses are the age old practice in arid region of India. Two distinct example of silvi-pastoral were seen in Bhadria (Jaisalmer) and Desnokh (Bikaner) districts where more than 500 ha area is under silvi-pastoral system. In these area due to over grazing perennial grasses become completely vanish and only *Z. numularia* remained, but again due to excessive browsing by Goat and Camel they were in a poor state. Harsh and Shankarnarayan (1981) studied effect of Sheep and Goat or gazing on the well managed of *Z. numulalria* with *Cenchrus ciliaris* slivi-pastoral system. They have reported that in Silvi-pastoral system grazing by mixed flock of Sheep and Goat recommended for the proper utilization of grasses as well as bushes. Sheep grazed only grasses and bushes remained unutilized, similarly Goat browse only bushes and grassed become unutilized and if both mixed together, than both component utilized equally. They have further recommended that in a well developed silvi-pastoral system 6 sheep and 3 goat/ha can be grazed round the year. However, in the recent past efforts have been made to improve the *Z. nummularia/Z. rotundifolia* by grafting/budding with improved variety of *Z. mauritiana* (cultivar Gola & Seb). If wild planted budded with Gola & Seb cultivar than within the same year good quality fruits can be harvested and from second year onwards 10-20 kg fruit/plant can be harvested. The high quality fruit prize ranged between Rs.5-10 per kg. If 200 trees maintained along with the crops/grasses, than minimum Rs.15,000-20,000/ha can be earned by sale of ber only in addition of crop/grass production. (Gaja *et.al.* 2004).

In the recent past *Ailanthus excelsa* has planted along with the agricultural crops. It was initially planted as fodder tree, as its leaves are eaten by sheep and goat. But recently its wood used in ply wood industries. The market price of green wood is around Rs. 75/ql. In Sikar distt. more than 20 industries established based on *A. excelsa.*

The alternate land use system is not only drought proofing but improve the livelihood of the people.

Table 2. Forage production and crack protein yield in silvi-pastoral and pure pasture.

System	Tree density/ha	Forage Production (Kg/ha)			Crude Protein Production (Kg/ha)		
		Grass	Trees (50 t/ha)	Total	Grass	Trees (50 t/ha)	Total
Cenchrus ciliaris Pasture land(Reseeded)	-	2500	-	2500 (313)	100	-	100 (333)**
Ciciliaris + Khejri	30	2250	450.20%	2700 (337.0)	90	69.0+57%	155 (517)
C..Ciciliaris + Khejri	50	2000	750.37%	2750 (344.0)	80	90+65%	170 (567)
C..Ciliaris + Bordi	750	2000	53-3%	2053 (257)	80	6.5 (12%)	86.5 (288)
C.Ciliaris + Bordi	1200	1750	109.0(6%)	1850 (231.0)	70	13.0 (2%)	93.0 (277)
Wheat+Ardu (Stover)*	80	2000 (Stover) 1600	2400 (66%)	6240 (780)	144	384 (126%)	528 (1760)

Protein requirement = 1gm/1kg wt. of Animal.
Fig in parenthesis shows grazing days /ACU* based on biomass and available

Table 3. Economics from the silvi-pastoral components after 7 years of establishment

Treatment	Fuel yield (q/ha)	Grass yield (q/ha)	Revenue from fuel wood (Rs.)	Revenue from grass (Rs.)	Total Revenue (Rs.)
S_1G_0	60	-	3,000	-	3,000
S_2G_0	32	-	1,600	-	1,600
S_1G_1	50	55.8	2,500	1,395	3,895
S_2G1	28	52.9	1,400	1,323	2,793
Grass without trees	-	46.0	-	1,150	1,1150

Table 4. Economics of Acacia tortilis based system after value additions (After 15 yrs).

nts	Fuel wood (Q/ha)	Grass yield (Q/ha)	Tree pods (Q/ha)	Timber CFT	Gum from trees	Revenue (Rs.)					Total Revenue (Rs.)
						Fuel wood @ 60/Q	Grass yield @ 100/Q	Tree pods @ 100/Q	Timber @ 200/CFT	Gum @ 100/kg	
	120	-	12.6	400	163	7,200	-	12,600	80,000	16,300	1,02,060
	100	-	16.5	300	140	6,000	-	1,650	60,000	14,000	81,650
	100	100	10.5	350	150	6,000	11,000	1,050	70,000	15,000	1,03,050
	80	100	14.0	280	130	4,800	10,000	1,400	56,000	13,000	85,200
	-	150	-	-	-	-	15,000	-	-	-	15,000

S_1= 200 trees/ha, S_2= 100 trees/ha, G_0= Without Grasses, G_1= With Grasses

Table 5. Gain per hectare when the farmer himself processes the fruits (300 kg)

Particular	Quantity Produced	Cost of Processing	Sale price of product	Gain	Total gain (Rs. ha^{-1})
Peelu squash	450 lit.	Rs. 960 @Rs. 32/lit	Rs. 18,000 @ Rs. 40/lit	Rs.. 8400	Rs. 8574
Fat from seed	9 kg	Rs. 90 @Rs. 10/kg	Rs. 180 @Rs. 20/kg	Rs. 90	
Oil-cake	21 kg	-	Rs. 84 @ Rs. 4/kg	Rs. 84	

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PROCESSING AND CONSERVATION OF FEED RESOURCES FOR LIVESTOCK FEEDING DURING DROUGHT

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Drought and its impact

Over the past few years, there has been a worsening incidence of the natural calamities increasing the vulnerability of the communities across the globe. One of the recurring natural calamities is drought and its impacts on the affected population are visible on slow growth rate and agricultural production. Indications of climatic changes reveal that vulnerability of drought may increase in coming years. Drought is a perennial and recurring feature in many parts of India, particularly arid zone. As per the reports from the Govt. of India about 68 % area of the country is prone to drought of varying degrees. The deviations in climatic and rainfall patterns in the country have triggered different effects on people's livelihoods. It can not be seen mere by a physical phenomenon. Each drought leaves a unique set of impacts, depending on its severity, duration, spatial extent, and also on ever-changing socio-economic conditions. The impact is on huge population spread over a large geographical area in a State or over many States for varying duration of time ranging from few months to several years. The impact of drought on livestock is manifested in four ways. (i) mortality (ii) loss in productivity (iii) health of animal and (iv) loss in fertility.

The drought of 2002 –03 arose following an unprecedented failure of rains from south – west monsoon in 2002, particularly in July 2002, when the country as a whole received 19 % deficit in rainfall, making that month as the driest over July in the annals of Indian Meteorological records. Arid and semi-arid regions constituting 40 % of geographical area are more prone to drought. The frequency of drought in 1/3rd arid areas is twice in five years, where as it is only once in five years in 2/3rd semi-arid region. Drought poses severe scarcity of water, fodder and food grains to begin with followed by nutritional disorders and sometimes casualties in extreme cases. During the drought of 2002-03 sheep and camels followed by cows were the most vulnerable animals (Table 1). They perished in large numbers ranging between 10 to 32% of the population. 25 to 50% of cows were abandoned due to starvation or put in charity centres because of acute shortage of fodder and finances.

Table 1. Growth and composition of livestock in Rajasthan (figures in million)

Year	Cattle	Buffalo	Sheep	Goat	Camel	Others	Total
1951	10.787 (42.3)	3.045 (11.9)	5.387 (21.1)	5.562 (21.8)	0.341 (1.3)	0.399 (1.6)	25.5 (100)
1961	13.136 (39.2)	4.019 (10.0)	7.361 (22.0)	8.052 (24.0)	0.570 (1.7)	0.371 (1.1)	33.5 (100)
1972	12.470 (32.1)	4.593 (11.8)	8.556 (22.0)	12.162 (31.3)	0.745 (1.9)	0.353 (0.9)	38.9 (100)
1977	12.896 (31.2)	5.072 (12.3)	9.938 (24.0)	12.307 (29.8)	0.752 (1.8)	0.394 (1.0)	41.3 (100)
1983	13.504 (27.2)	6.043 (12.2)	13.431 (27.1)	15.480 (31.2)	0.756 (1.5)	0.436 (0.9)	49.6 (100)
1988	10.916 (26.7)	6.340 (15.6)	9.913 (24.2)	12.593 (30.8)	0.721 (1.2)	0.418 (1.0)	40.9 (100)
1992	11.639 (24.0)	7.765 (6.0)	12.497 (25.1)	15.352 (31.8)	0.744 (1.5)	0.454 (0.9)	48.5 (100)
1997	12.159 (22.4)	9.756 (18.0)	14.312 (26.3)	16.937 (31.2)	0.668 (1.2)	0.490 (0.9)	54.3 (100)
2003 % change 1977-03	10.871 (22.2) -10.6	10.511 (21.5) 7.7	9.759 (19.9) -31.81	16.774 (34.3) -1.0	0.497 (1.0) -25.6	0.480 (0.10)	48.9 (100) -10.0

Goats and other small animals are also affected by drought, but relatively mildly compared to large animals. They are mainly grazing animals and depend on common property resources i.e. grazing lands, wastelands, forests etc. Moving to better-endowed areas saves them. Migration of small animals is traditional practice in Rajasthan. In case of widespread drought, they are taken out of the State, and in the worst situation sold for slaughter, as there is a round the year market for them. All caste, class and economic categories of household keep small animals for milk and ready cash. However, their health is affected by loss of vegetation of their choice. When rain comes, there is a change in type of vegetation for grazing and few animals cannot adjust and die (10% of the total number, as reported by people).

Livestock is the main source of income in arid zone as cropping is not a dependable proposition. However, beside water and food grains, scarcity of fodder is one of the main issues encountered during drought period. The livestock being an important asset and equally affected by drought the state also arranges fodder for cattle incurring the heavy expenditure on transportation and purchase of fodder (Table 2).

Fodder and feed availability

Availability of fodder and feed resources in the region is usually much below the requirement. According to one estimate, the availability of green fodder in the western dry zone of the country is 26.83% of the requirement, that of dry fodder 12.41% and concentrates 5.86%. The situation worsens during the drought, especially in the arid areas. Estimation for western Rajasthan suggests that with current practices the fodder

Table 2. Item wise expenditure on drought relief works in Rajasthan (Million Rs)

Item	1999-00 AE	2000-01 AE	2001-02 AE	2002-03 AE	2003-04 BE	2003-04 RE	2004-05 BE
Gratuitous relief	0.00	27.9	18.45	171.45	29.52	63.0	19.35
Drinking water	8.1	10.8	19.35	17.55	31.95	92.25	22.05
Supplementary nutrition	0.00	0.00	0.00	0.00	0.00	293.4	0.00
Fodder supply	18.45 (0.76)*	213.75 (4.3)*	162.45 (5.1)*	1561.5 (36.7)*	504.0 (28.7)*	2062.35 (23.5)*	122.4 (5.0)*
Animal health	0.00	0.00	0.00	24.75 (0.6)*	49.05 (2.8)*	11.25 (0.1)*	19.35 (0.8)*
Public health	0.00	27.9	0.00	203.4	0.00	342.45	0.00
Other expenditure	2648.25	4690.8	2959.65	2274.75	1143.9	5901.3	2277.45
Total	2675.25	4970.7	3159.65	4253.85	1758.15	8766.0	2461.05

Actual Expenditure (AE); Budget Estimate (BE); Revised Estimate (RE)
*Figures in parentheses indicate %age of total expenditure

deficit during normal years would be as high as 60% of the demand, and might range from 55% in the western districts of Bikaner, Jaisalmer and Barmer to 69% in the central districts of Jodhpur, Nagaur and Churu, and 72% in Pali, Jhunjhunu and Sikar districts. During drought years the overall deficit might go as high as 76% of the demand, and range from 76% in western districts to 81% in the central districts and 82% in the eastern ones. The northern districts of Ganganagar and Hanumangarh are likely to face a deficit of 24% during normal years and 50% during drought years.

In almost all the districts of western Rajasthan fodder situation during 2002-03 was very bad. The major sources of fodder during normal years are the crop residues, as well as the natural vegetation in current fallows and uncultivable lands. The permanent grazing lands (Orans) are usually in a severely degraded state, are heavily encroached, and are not always counted for fodder availability. The exceptions are the very few managed ones. Under such a scenario, the almost total crop failure during Kharif 2002, and drying of natural vegetation in the fallow lands meant a fodder crisis in many districts.

Types of fodder available

During normal rainfall year crop residues viz., bajra (pearl millet) *kadbi*, dry leaves & plant of green gram, mothbean, clusterbeans, wheat straw etc. become the main source of animal feed. Besides, grasses, tree based top feed, *pala* (leaf fodder of *zizyphus numularia*), *loong* (leaf fodder of *Prosopis cineraria*) and wheat straw are also available for consumption. However, during drought period the availability of crop residues is reduced drastically due to crop failure.

Regeneration and re-growth of natural vegetation are also affected severely under drought, especially because of non-availability of moisture and due to higher incidence of browsing, lopping and cutting of trees and shrubs for fodder and fuel purposes. For example, in Bikaner district regeneration of *Cenhrus setigerus* (*Dhaman*), *Cenchrus biflorus* (*Bhurat*) and *Dactyloctinum sindicum* (*Gathiyan)* grasses was badly affected during drought of 2002-03. *Panicum antidotale* (*Murath*) failed to sprout properly on the sand dunes, but *Lasirus sindicus* (*Sewan* grass) performed satisfactorily in sandy habitat. In neighboring Churu district *L. sindicus* failed to regenerate properly, while *C. setigrus* and *C. setigenrus* experienced a reduced vigour and density.

Issues of grazing and fodder availability

Grazing of animals is fast becoming a major societal issue in rural areas of western Rajasthan that often reaches a flash point. With increasing population, fragmentation of crop lands and decreasing fallow there is now fewer areas left for uncontrolled grazing by the large herds of sheep and goats. Most of the permanent pastures (*Orans* and *Gochars*) in the region are in a severely degraded state that makes conditions worse. Pastoralists (nomadic cattle rearers/breeders) who take their animals on annual migration to the greener parts of the state and outside are facing increasing resistance from the farmers which sometimes lead to clashes.

Thus, animals are the most sufferers during drought period both with respect to fodder/feed and water. In situations it becomes imperative to process the available fodder, store and conserve the feed resources for consumption of livestock during drought period.

Indigenous techniques of fodder storage in western Rajasthan

Karai: Karai is one of the indigenous methods of fodder storage in western Rajasthan. In this method fodder can be stored safely upto 10 years. The *karai* is made slightly away from the village. Locally available material is used for making the *karai*. It is made in such as way that the stored feed is safe from sun, rain water and high wind storms and also from human and animal's attack. The *karai* is conical in shape with 3-4 m dia at the base and 8 m height (Fig. 1). At the base pearl millet "*bhani*" and mustard straw is kept to safe guard the stored fodder against termite. The *karai* is covered with *Jhumpi* made of pearl millet stalk and is replaced every third year. The *karai* is provided with 0.5 m wide 1-1.5 m, deep trench around it to safeguard against domestic as well as wild animals.

Pachawa: Pachawa is one of the indigeous techniques of fodder storage in arid region. The capacity of the *pachawa* is as high as 1000 q. The shape of *pachawa* at the base may be circular, square or rectangular (Fig. 2). The square/rectangular shape pachawa may be consumed slowly with time whereas the circular shape *pachawa* once open is to be chafed in pieces and stored in room/covered space and / or to be sold/consumed. The *pachawa* is erected on a raised floor to safeguard against rainwater and away from the hutments to minimize the risk of fire. While erecting the *pachawa* its longest side should be kept parallel to the commonly blowing winds to avoid any over turning.

Fig. 1. Traditional storage of straw / *pala (Karai)*

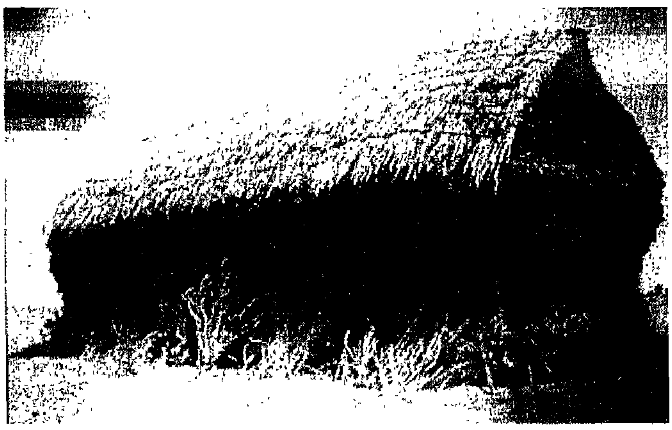

Fig. 2. Traditional storage of pearl millet stalk and other crop residues (*Pachawa*)

Mustard and sesamum's stalk alongwith other dry grasses are spread over (1-1.5 m thickness) raised floor to safeguard against termite. Total height of the pachawa is kept around 6-8 m whereas width is kept around 4-5 m. After attaining the height (6-8m) the top surface is made like inverted "V" and is covered with thatched roof (V-shape) made using the pearl millet stalks and other locally available materials. This roof is replaced every third year. The roof cover is extended all around in such a way that the stored fodder do not come in contact of rain water. The *pachawa* is provided with dry branches of thorney plant upto 2-3 m height and an open trench 0.5 m wide & 1-1.5 m deep around it provide safety against domestic as well as wild animals.

Denisifcation and brequetting of fodder/feed

As fodder is a low density material its transportation, handling and storage not only become problematic but also require large storage space. India produces 540 million tones of crop residues annually, which could be used for feeding the country's animal production. There are regions with deficit and excess production of these crop residues in the country. The feed management, with roughage diety would improve manifold if processes are developed such that deficit and disaster prone areas could be stocked with processed animal feed.

Baling/densification of grasses/crop residues

The grasses/crop residues can be densified/baled to 1/3rd of its original volume and stocked/stored for use during lean period/deficit areas(drought prone areas). The baling is generally done slightly at high moisture content. A tractor drawn baling machine was developed at CAZRI (Fig.3). 50 x 50 x 50 cm block/bale can be made using this machine. Feed processing units are available for pelletization of concentrate. However, these units can not handle a feed mixture having large sized straw; high proportion of chopped fodder and crop residues Engineering Division of IARI has developed a machine for moulding animal feed into compressed blocks using a whole range of crop residues, feed supplements and suitable binders.

Fig. 3. Tractor drawn straw / grass bailing machine

A prototype machine for compaction of biomaterials using hydraulic cylinders for application of compaction pressure upto 425 kg/cm^2 was designed and developed (Fig. 4). It is powered with a 25 hp electric motor to run its hydraulic system. Properly sized animal feed material is placed in the hopper of the machine. The quantity of feed is calculated according to the volume (20 cm x 20 cm x L (thickness) and the density desired of the feed block. The output capacity of the machine is 250 kg/hr. The machine can densify the feed material upto 1/4th to 1/5th times of the original volume. The volume reduction of individual raw feed material is presented in Table 3. From the table it is clear that the machine is capable of the reducing the volume of feed material in the range of 4 to 42 times. The cost of feed block formation is Rs 400 per tonne.

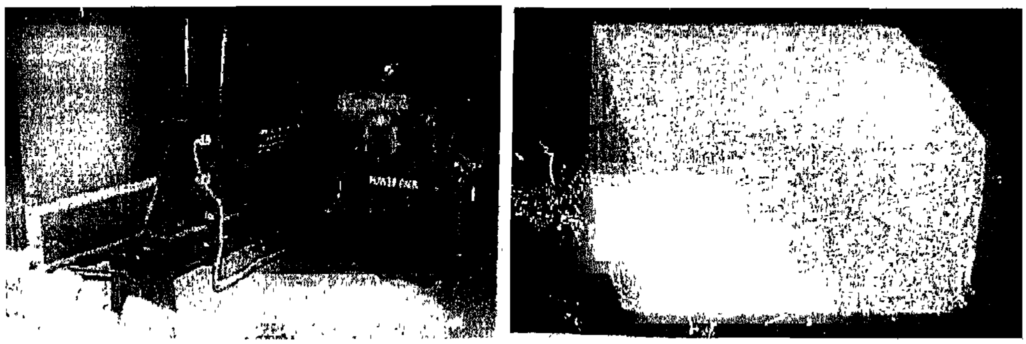

Fig. 4. Prototype of animal feed block formation machine

Advantages of complete feed blocks

1. Ease in handling of feed materials and saving of labour in feeding
2. Require less transportation and storage space
3. Less transportation and storage cost
4. Reduction in wastage of crop residues
5. Offer scope for incorporation of hard or large-size feed materials into feed blocks
6. Offer scope for ration manipulation according to the requirement of animals
7. Prevent selective eating by animals
8. Useful to induce animals to consume proper proportion of roughages and concentrates for optimum performance
9. Since feed material becomes soft under compression, animals prefer eating blocks
10. Milk yield and fat contents increase on feeding complete feed blocks

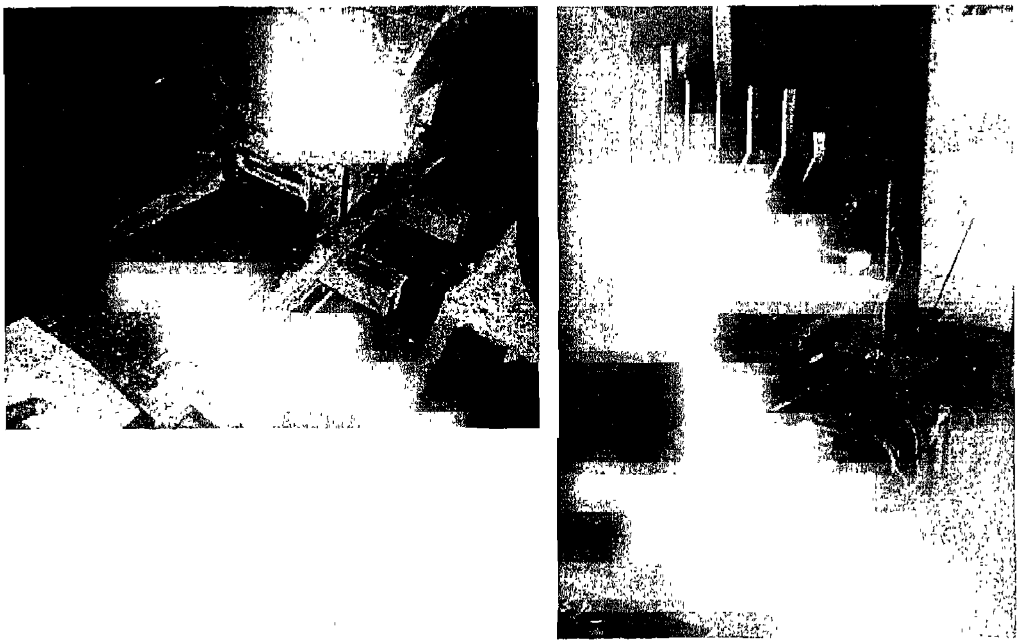

Fig. 5. Experimental unit of continuous type feed block making machine

Table 3. Bulk density and volume reduction of raw feeds and blocks at compaction pressure of 300 kg/cm and moisture content of 12% (wb).

S. No.	Feed / crop residue	Bulk density of feed (kg/m²)	Bulk density of feed block (kg/m²)	Volume reduction factor
1.	Groundnut straw	81.00	553.63	6.8
2.	*Ardu* leaves	51.50	539.06	10.4
3.	Mustard straw	51.48	562.21	10.9
4.	Gram straw	66.48	471.94	7.1
5.	Wheat straw	51.20	305.22	5.9
6.	Wheat straw with 5 % molasses	57.00	443.50	7.8
7.	Sorghum straw	70.00	437.20	6.2
8.	Paddy straw	70.00	279.00	3.9
9.	Forest grass	66.33	503.00	7.6
10.	Pearl millet	119.60	511.10	4.3
11.	*Cenchrus* grass	67.50	486.84	7.2
12.	*Arhar* straw	55.00	689.06	12.5
13.	Sugarcane baggase	61.00	567.50	9.3
14.	Cluster bean	109.00	596.67	5.5
15.	Mango leaves	17.00	643.20	37.8
16.	*Khejri* leaves	67.50	542.00	8.0
17.	*Pala* leaves	65.50	538.40	8.2
18.	Maize (*chopped*)	90.70	520.80	5.7
19.	Sugarcane top with mustard cake 10 % + molasses 10 %	105.00	422.00	4.0
20.	*Sewan*	91.60	700.00	7.6
21.	Groundnut haulm	77.10	500.00	6.5
22.	*Moth chara*	84.70	901.00	10.6
23.	Cotton stalk	140.00	785.00	5.6
24.	Rice bran	361.00	1197.00	3.3
25.	Hay (*Barseem*) chopped	55.00	1050.00	19.0
26.	Korean lawn grass (*Zoysia japonica*)	38.00	597.00	15.7
27.	*Doob* grass (*Cynodon dactylon*)	15.00	630.00	42.0
28.	Maize cob (*ground*)	498.00	843.00	1.7

Brequetting of animal feed

As availability of green fodder is only 27 % against requirement in the Western Rajasthan the animals are ill fed particularly during drought period. To overcome the problem the farmers supplement the feed deficit by multi nutrients feed block / concentrate at least in case of milch animals. Batch type multi nutrients feed block making systems are available. For large scale production of feed block (wheat bran, guar brokens, guar-gum, dolomite, mineral mixture, common salt, urea, molasses, water) continuous type machine is required. Experimental unit of the continuous type animal feed block making machine has been designed and developed at the CAZRI (Fig. 5). About 40 blocks (25 x 15 x 7.5 / 5.0 cm size) per hour can be made with this unit.

WATER REQUIREMENT AND WATER USE EFFICIENCY OF DIFFICULT AND NORMAL WATER IN ARID LIVESTOCK

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In order to survive and reproduce in an environmentally hostile arid region frequented by moderate to acute droughts in almost alternate years, an animal must possess the necessary physiological skills to deal with varying deficiencies of potable water and feed resources; and wide spread hyper saline water coupled with high thermal heat load or develop skills as acclimatization progresses. A breed originated in a rather humid region with less water use efficient system and coping system to hyper saline water should not be expected to suddenly do well in such arid region. Before searching an efficient and appropriate physiological make-up of animals for arid region, it is worth mentioning here that polyfunctionalism exists in respect of body water, energy and protein turnover rate efficiencies in sheep and goats, which will allow considerable selection of the most hardy low producing animals for the drought prone arid region. It is now well established that animals, which have high rate of water use also have high rate of energy and protein use and *vice-versa*. Hence, animals may be reared for two purposes- (I) Low producing animals (drought hardy) with low water, energy and protein requirements, and (II) high producing animals (drought susceptible) with high demand of water, energy and proteins.

Environment and Animal

In the arid region of western Rajasthan average air temperature during the peak summer and winter may vary between 45-48°C and -5 to 20°C with 12-18% minimum relative humidity of the air. The region also has high wind velocity during summer and monsoon, ranging from 13-14 km hr^{-1}. Scanty and erratic precipitation and a high rate of evapo-transpiration lead to insufficient recharge of the underground water and supplies. Soil and water salinity is also moderate to high at several places in the region leading to high rate of mortality of animals due to nitrate poisoning and incidences of flourosis.

In any case all livestock, except high yielding dairy cattle and buffaloe, which enjoy the care and attention of their human masters, need to graze or browse for an average of 6-8 hours per day on community range under the sun during peak summer. Since it is not possible to convert this harsh environment to a hospitable one where an animal may express its full genetic production and reproduction potential, it is during this period that their claim to desert habitation is tested.

Heat and water relationship

Most of the livestock are not able to store heat during day time and dissipate it during relatively cool evenings and nights by physical means i.e., radiation, conduction or convection. Sheep and cattle are thermo stable and depend mainly on the expensive water evaporative cooling mechanism. Camel and to some extent black Marwari goats, are thermo labile and dissipate most of their heat load during cool hours of the evening and nights mainly by radiation. A 500 kg camel and 30 kg Marwari goat can store about 2500 kcal and 830 kcal in a day when their body temperature increase by 6°C and 2°C, respectively. The camel and goat do this very conveniently to save the precious water.

As regards to drinking water, large variations are observed among individual animals in their water requirements. Such differences are influenced by nature of the feed consumed, environmental temperature, humidity and physiological conditions of the animals. Adding proteins, minerals and salts to the diet may increase water requirements as the body must expel the metabolites and excess salts through the kidneys by way of urine.

Under arid conditions, livestock in general drink water about double the quantity of the air dried feed ingested by them. On dry matter basis, sheep, goat and cattle usually consume feed at the rate of 2.5% of their body weight day^{-1}. Thus, the daily water intake of these animals comes to about 5% of their live weight. The normal average water intake of Marwari goats during summer, winter and the post-monsoon season has been recorded as 8.3, 6.3 and 5.6 l 100 kg^{-1}, respectively (Ghosh and Khan, 1980). African goats consume water at the rate of 8% of their body weight day^{-1}. Camel and donkeys drink water at the rate of 5 to 6% and 8 to 10% of their body weight during winter and summer, respectively. In some areas where dew is more common and heavier, it could be an important source of free water for livestock.

Rise in environmental temperature from 16 °C to 30 °C at 60% to 70% relative humidity led to increase in daily water intake, evaporative water loss, urinary out put and total body water in Friesian bull (Shebatia et.al., 1992). The water intake has been found to be significantly increased to 16-20% after 6 km grazing in goat and sheep during summer (Khan & Ghosh, 1989). Water intake also increased significantly in lactating sheep (El-Sherif and Hassanaein, 1996) and on high salt load (El-Nouty, et.al., 1988, Abdel-Samee, 1996).

Maintenance of body weights during absolute and intermittent water deprivation

Acute water restriction

Of the various physiological responses during water stress as revealed by various experiments is the loss in body weight of dehydrated animals. During summer (34-38 °C) the Marwari goat, on an average lost only 1.5% of its body weight per day while the Marwari sheep lost as much as 6% per day. In another study when the Marwari sheep was put on 2 days dehydration regime during summer, it had lost its body by 11% on its first day of dehydration and by 6% on the second day of dehydration. Bedouin goats had lost 32% (on an average of 8% day) of their body weight after 4 days of dehydration. In another study, however, when absolute water deprivation was imposed for 4 days at an environmental temperature 35 °C on goats weighing about 40 kg, the animals lost about 3% of their body weights per day (Khan *et al.* 1979). The secret to dehydration tolerance in lean animals, however, seems to be because of their initial higher body water contents, which is perhaps used for various body functions during dehydration. It seems that young animals with low body weights and fat contents, but higher body water contents put more resistance to water deficiency conditions than the old animals with higher body weights, fat contents and lower body water contents. Reports from Australia indicate that during water deprivation, shorthorn cattle lose about 8% of body weight per day; Merino sheep about 4-5% per day and camels about 2% per day. This would put the Marwari goats in a category very similar to that of the camel in respect of body weight maintenance during absolute water deprivation.

Partial water restriction

When maintained under partial water restriction (1/4 of the normal) schedule during one year period (summer to summer), the Marwari goats usually gain in body weight. It has been estimated that with a flock of 100 adult goats about 171 l of water/month may be saved, or 400 goats may be kept on the water ration of 100 without any ill effect, by limiting the daily intake of the animals to a quarter of what they would normally drink.

Intermittent water restriction (Watering after every 4th day)

After the monsoon till the next summer, the Marwari goats receiving water after every 4th day did not show any ill effect either on body weight or on their general performance. The percentage increase in body weight of Marwari goats over the period was 59% and 48% for the daily ad lib. watered and after 4 days ad-lib. watered goats respectively. The average water consumption of animals watered after 4 days was about 3 l/100 kg b.wt./24 h, while the daily watered goats had an average intake of about 6 l/100 kg/b.wt./24 h. Apparently these animals, when watered after every 4th day, perform better than the Marwari sheep, which under water restriction reportedly lost, on an average, 6 per cent of their body weights per day. However, it has been observed that intermittent (twice a week) watering in Marwari and Magra sheep does not in anyway affect their body growth or productivity (Ghosh and Abichandani, 1981), besides a considerable saving of drinking water.

Watering after every 5th day

Effect of intermittent watering (watering ad lib. after every 5 days) on the maintenance of body weights of Marwari goats and Marwari sheep was studied for 3 years. During winter season, the Marwari goats watered ad lib. and after every 5 days registered no losses in their body weights. However, the same animals lost their body weights to the extent of 10-12% during summer but their feed consumption remained unaffected. On the other hand, the Marwari sheep watered ad lib. after every 5 days, not only lost their body weights during summer (about 20%) and winter (about 10%) but their feed consumption was also decreased during these two seasons, though less during winter, but more during summer. When compared between sheep and goats, the sheep consumed more drinking water (about 29% during summer and 22% during winter) than the goats, when maintained on a schedule of watering after every 5 days. However, neither the sheep nor the goats could tolerate water restriction for 5 days when the environmental temperature rose beyond 40 °C and therefore, this schedule of intermittent watering requires constant vigil on the environmental temperature while maintaining these animals on such intermittent watering schedule.

Body water distribution pattern

The distribution of water in various compartments in normally watered desert animals has been reported by several workers (Kataria et.al., 2003, Hammord et.al., 1990, Shkolnik and Choshnaik, 1985, Khan and Ghosh, 1989 and Dusshea et.al., 1990). The Marwari sheep and Marwari goat have almost similar plasma volume (PV) and total body water (TBW). However, extracellular fluid volume (SCN space) - a very important water compartment for combating water stress is significantly higher in the Marwari goats than in the Marwari sheep. In the Beduin goat PV and TBW are significantly higher than in Marwari sheep and Marwari goat, but SCN space is lower in the Beduin goat than in the Marwari goat. The Indian desert camel, however, has higher levels of PV, Cell and Gut water and TBW than in the Marwari sheep and Marwari goat. Such species or breed differences with regard to various body fluid compartments may be attributed to the inter-species differences in the mechanism of body water regulation during water deficiency conditions.

Physiological manoeuvring under insufficient water supplies

For any desert animal, the maintenance of circulatory volume is of great importance under water deficiency conditions because of two reasons: (i) to avoid circulatory failure, which may occur if the blood gets thick and, (ii) to dissipate the internal body heat through the circulatory medium. During water restriction, water lost from the body of an animal is drawn from various body water compartments and the degree to which these compartments are depleted during dehydration differs from species to species. For example, in Marwari goat 4-days of water deprivation during summer lowered the plasma volume (PV) by 13% of normal. In Marwari sheep, on the other hand, PV was reduced by 43% under similar environmental conditions (Table-1). The Australian Merino sheep also lost about 45% of PV after 5 days of water deprivation. The actual mechanism involved in the retention of plasma water in the goat (Khan & Ghosh, 1985) and also in the camel (Kataria et.al., 2003) appears to be associated with the retention of plasma proteins, particularly, albumin, in the vascular bed.

Unlike Macfarlane's Merino and the Marwari sheep, which had severe reduction in the SCN volume at the end of dehydration regimes, the Marwari goat tends to conserve its SCN volume some what more efficiently, there being a reduction of SCN volume by only about 8% (Khan, *et. al.*, 1979). In the Marwari goat the reduction in the cell and gut water is of the order of 41% at the end of 4-day dehydration regime, while in sheep it may be to the extent of 30% only. Cell and gut water is of special significance during periods of water stress in the Marwari goat because it is this water, which is mainly relied upon by the animal for maintaining its normal circulatory volume (Khan, *et. al*, 1979). The cell and gut water may, thus, be considered as "Emergency Water Reservoir" which is used to avert the circulatory failure in the goat. The inability of sheep to use this water fully at times of water crisis and its primary dependence on circulatory water for evaporative cooling and other essential purposes, makes the sheep decisively less desert worthy than the goat.

Table 1. Body fluid components (Mean± SE) in normally watered and water restricted Marwari goats

Parameters	Body water (l) Before water Restriction (Mean± SE)	After day 4- of water Restriction (Mean± SE)	Change of complete water restriction from *Ad-lib.* value (%)	Water (l) lost (Mean± SE)	Percent of the total body water lost
Body weight (kg)	40.10 ± 0.75	35.30± 1.08	(-) 11.97	-	-
Total body water (l)	24.46 ± 1.53	18.21± 1.09	(-) 25.55	6.24 ± 2.11	---
Plasma volume (l)	1.47 ± 0.03	1.28 ± 0.05	(-) 12.92	0.19 ± 0.07	3.04
Blood volume (l)	2.03± 0.07	1.93 ± 0.06	(-) 4.92	0.14 ± 0.05	2.24
Extra-cellular fluid volume (SCN space) (l)	11.49± 0.22	10.62± 0.32	(-) 7.57	0.90± 0.28	14.42
Cell and gut water (l)	12.96 ± 1.52	7.59 ± 1.03	(-) 41.43	5.58 ± 1.80	9.42
Interstitial fluid volume (l)	10.02 ± 0.19	9.33± 0.31	(-) 6.88	0.71± 0.27	11.37

When deprived of drinking water for as long as 13 days during late winter, Marwari goat showed an extraordinary ability to maintain its body fluids, whereas Marwari sheep almost reached its limit of physiological tolerance by the end of this period. The rate of body water loss in the goat, sheep and the donkey was 46, 87 and 99 ml $kg^{-1}day^{-1}$, respectively, during the dehydration regime. During dehydration regime, a rank order in respect of maintenance of SCN volume in these species has been noted as : Marwari goat < Marwari sheep < Desert donkey. Of the total amount of body water lost, the cell and gut water of the sheep contributed to the SCN space was 24% only in contrast to 80% in the goat (Khan, et.al., 1979) and the camel (Macfarlane et.al., 1963 and Kataria et.al., 2003). Interestingly, it is the interstitial fluid volume (IFV), which contributes about 60% to the depleting extra cellular fluid compartment in sheep.

Body water and its turn over rate

Total body water in Marwari sheep, Marwari goats and Parbatsar goats has been found to be 52.9%, 58.5% and 61.6% of body weight, respectively. In Sahelian goats and Maradi goats and Bedouin goats (Shkolnik and Choshnaik, 1979) it was 77.8%, 66.1% and 76.3% of body weight respectively. TBW in Uda and Yankasa, Merino,, Awassi and Ogaden sheep (Macfarlane, 1982) was 80.5%, 73.5%, 63.9%, 71.5% and 73.5% of body weight, respectively. It appears that Indian desert sheep and goats have significantly less TBW in comparison to exotic sheep and goats inhabiting the arid region.

The data revealed considerable variation in body water turnover rates (BWTRs) in different breeds of Indian desert sheep and goats. The Marwari sheep turned over nearly 17 per cent more water per day than the Marwari goats. Parbatsar goats and Marwari sheep, however, have more or less similar body water turnover rates i.e., 185.1 and 172.0 ml/ $kg^{0.82}$/day. Published reports generally ascribed lower BWTRs in desert-adapted goats like, Sahelian goats and Maradi goats (Aganga et.al., 1989), Beduin goats and Baladi goats (Shkolnik, et.al., 1979) than the desert sheep like, Barki Rahmani sheep (El-Nouty et.al., 1988) and Marwari sheep (Khan and Ghosh, 1983). The body water turnover rate in Marwari goat (147.0) was significantly lower than the Parbatsar goat (185.0), Somali goats (185.0) and East African goats (319.0).

Young Marwari and Magra lambs, Marwari and Parbatsar kids have high total body water than their adult counterparts. Young Ungulates and Merino lambs have also been found to have higher total body water than their adult counterparts. In other words, total body water per unit body weight decreases with age. The progressively lower water content during the growth period is probably related to increased synthesis of connective tissues that are less hydrated as compared to muscle tissues. Lean tissue contains 72% water, whereas adipose tissues have only 20% water. BWTRs were also significantly higher in Marwari lambs and kids than their adult counterpart. A similar age effect in respect of BWTR has been reported for Merino sheep. Female Marwari kids tend to have higher rates of water turnover than male kids do.

Table 2. Body water and its turn over rate in normally hydrated, dehydrated and rehydrated animals

Species	Parameters	Normal (Mean ± S.E.)	Dehydration (Mean ±S.E.)	Re-hydration (Mean ± S.E.)
Marwari goats (4)	Body water (% B. Wt.)	53.57 ±1.75	51.48 ±1.26	51.10 ±1.72
	BWTR (ml $kg^{0.82}$ day^{-1})	116.41± 2.03	11.59± 0.65	124.22± 2.66
Marwari sheep (4)	Body water (% B. Wt.)	59.73 ±0.93	53.69 ±0.06	59.29±0.88
	BWTR (ml $kg^{0.82}$ day^{-1})	120.21± 2.14	12.47± 0.70	146.72 ± 5.68
Marwari donkey (2)	Body water (% B. Wt.)	53.09 ±4.35	42.84 ±0.62	48.52 ±1.48
	BWTR (ml $kg^{0.82}$ day^{-1})	170.34 ± 11.68	21.32± 0.37	170.34 ± 11.68

Among Indian desert livestock species, a significant ($p<0.05$) rank order was observed in respect of water turn over rates in hydrated and rehydrated sheep, goat and donkey (Table-2). It was lowest in Marwari goats and highest in donkeys; Marwari sheep occupied a middle position. Positive correlation between BWTR and heat load has also been observed in sheep, goat and donkey of the Indian desert (Khan and Ghosh, 1983) and Oryx and Eland antelopes of the African arid zone. Body water turn over (BWTR) estimates suggests that the Marwari sheep turned over nearly 17% more water per day than the Marwari goat. The Parbatsar goat also of the Rajasthan desert, however, behaved similar to the Marwari sheep in this respect. The rate of body water turn over in the Marwari goat would appear to be lower than that reported for goat breeds from other dry regions like, Australia and Israel.

BWTR values provide an understanding of adaptive animal-environment eco-physiological interaction processes, which might have developed millions of years ago. These adaptations make evolutionary distant livestock such as camel and black coloured goat, survive in arid environments with great success and economy, whereas others, such as cattle and sheep survive with more expenditure of water and energy. Considering the water use functions of different livestock species, it is obvious that camel and goats, followed by sheep, are the most economical animals to raise in the desert.

Hypersaline water use

Problem of high nitrate and fluoride in underground drinking water is acute in western Rajasthan. 60-64% wells have exceeded permissible limits of total soluble salts, fluoride, nitrate, chloride and sulphate contents. Consequently intake of such hyper saline water spread in large areas of arid region often leads to high mortality of animals, particularly during summer. Therefore, it is imperative to ascertain adverse effects, if any, of high intake of fluoride, nitrate, chloride and sulphate, the main constituents of saline water, on the overall productivity of animals and also on kidding/lambing and their growth rates.

The experiment on the effects of hyper saline water intake was started with synthetic saline water containing nitrate (8 g), fluoride (24 mg), chloride (6 g) and sulphate (2.4 g) animal^{-1} day^{-1} in sheep and goats for 1 year period. After having recorded its safe limit the concentration increased to 30 mg fluoride + 6 g nitrate + 7 g chloride + 15 g sulphate animal^{-1} day^{-1}. Later on the concentration of salts increased to 60 mg F, 12 g $N0_3$, 7 g Cl, and18 g $S0_4$ animal^{-1} day^{-1}, which was found to be safe in desert sheep and goats. No adverse affects either on body weight of adult animals, body growth of lambs and kids or blood constituents like, plasma proteins, albumin, globulin, A/G ratio, %PCV, Hb, inorganic phosphorus, alkaline phosphatase and Methomoglobin were observed. Here after the concentrations of these salts were increased to 80 mg F + 16 g No_3 + 10 g Cl + 20 g So_4 animal^{-1} day^{-1}. At this level of salt concentration also no adverse effects on body weights of adult sheep and goats, birth weight of kids and lambs; and body growth rates of these lambs and kids have been observed. Also no stillbirth, abortions were recorded in saline treated animals.

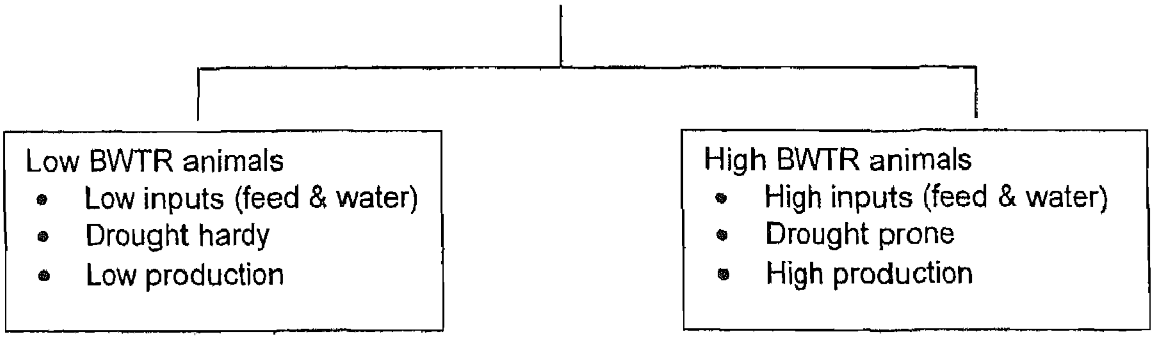
It is concluded that hyper saline water containing 80 mg F + 16 g No_3 + 10 g Cl + 20 g So_4 animal^{-1} day^{-1} is safe to Marwari sheep and goats.

Water use polyfunctionalism

When the introduction of design of different animals for arid ecosystem is contemplated, it is necessary to consider the genetic and evolutionary setting of rate functions of the animals. The nearer the rate of use of water, energy and protein to the supplies of these materials in the desert, more likely the animal is to survive. On the other hand, if large turnover of animal products are required, then high turnover rate animals can be contemplated but then survival is likely to be short in any time of insufficient supplies of either food or water. Such high turnover animal systems can only find comfortable place in areas where the supplies of feed and water are normal.

Within any species or breed, there is a degree of water use polyfunctionalism, which may allow considerable selection of the most viable and productive animals for the arid environment. This means that there are some low producing animals in any species or breed of animals which function with lower amounts of water and energy inputs. On the other hand there are high producing animals with high demands of water and energy. These two kinds of animals may be selected and bred as (i) drought hardy animals with low production and, (ii) drought prone animals with high production.

Body water Polyfunctionalism



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MANAGEMENT OF WATER RESOURCES AS A DROUGHT PROOFING MEASURE FOR LIVESTOCK

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Introduction

The State of Rajasthan is the largest state in India covering 342.2 million ha area i.e. 10.5% of country's geographic area but sharing only 1.15% of its water resources. The state is predominantly agrarian as 70% of the livelihood depends on agricultural based activities. Of five agro-climatic zones in the state three are arid or semi-arid, covering more than 60-75% area and northwest region of the state is practically desert. Three fold spurt in human population in last 20 years and doubling of livestock population has put tremendous pressure on fragile water and land resources. Recurring and prolonged drought particularly in arid zone is regular feature once in 2.5 years. During 1901-2003 the state experienced 36 agricultural droughts in one or the other part. Recently introduced canal irrigation commands only about 0.9% of potential net sown area; other resources such as well and tank irrigation are also gradually shrinking making livestock based farming system primarily rainfall dependent.

Water Harvesting Potential for Drought Proofing

The arid zone of Rajasthan is highly vulnerable in respect of water resources due to its geographical setting and recurring droughts. In order to maintain domestic water availability for growing human and livestock population and sustenance in agriculture production there is pressing need to evolve suitable strategies to enhance water capital and its judicious use. Based on detailed field investigations and processing of voluminous data the following recommendations have emerged to bring sustainability in water sector in Rajasthan.

- Drought is a historical reality in Rajasthan particularly in western arid region. The State will continue to experience it in future also. With the traditional drought mitigation strategies it is difficult to sustain the demand of water, food and fodder for growing human and livestock population. For feed and fodder security it is essential that water should be properly managed for enhancing productivity of crop and range lands for the sustenance of local population.

- Increasing demand for water and shortfall in surface water resources has put tremendous pressure on groundwater resources. At present, with intensive well irrigation and domestic water needs annual groundwater exploitation is much more than the recharge. It is estimated that in last 20 years nearly 22.5 BCM static water reserve has been exploited and if the present trend continues it will be difficult to meet water requirement for future generation on sustainable basis. This situation will be turning dangerous during drought years.

- The current rate of annual exploitation of ground water is higher than its recharge. On average there are severe or moderate flood once of five years, even if 10% of flood water is diverted to ground water, it will rejuvenate aquifer exploitation in five years at current rate. This may be achieved by adopting large scale groundwater recharge technologies in predefined time frame.

- The water scarce state of Rajasthan has in store traditional wisdom in water management to combat drought. These novel systems of water harvesting like *bawari, jhalara, nadi, tanka, khadin* etc. prevalent in the region over centuries are still viable and cost effective. If these systems are improved and utilized on large scale they can meet human and livestock water requirements to a large extent and mitigate drought impact at least partially. Besides, the modern rainwater technologies such as anicut, percolation tank, injection wells, sub-surface barriers are highly effective in rejuvenation of depleted groundwater aquifers in their operational zones. With the existing and proposed rainwater harvesting structures in Jodhpur district over 68 MCM, net water will be available even during severe droughts which may suffice to meet nearly 69 % of drinking water requirements in villages.

- Water and soil conservation through agronomic cum engineering measures is basic and need integrated to all. Other measures of water management, contour cultivation inter row and inter plot water harvesting, different kinds of bunding, bench terracing in conjunction with cover cropping, intercropping, strip cropping and appropriate land use practices enhance water conservation, productivity of crop and range lands, and also recharging aquifer over a long period. These have to be adequately attended.

- Water sector is dealt by several Government Department and organizations, and therefore, there is need for appropriate institutional arrangements for coordination in the management of water resources for feed and fodder security and drought mitigation. The role and responsibilities of these organizations should be clearly defined to avoid overlapping and to ensure active management of water resources at all levels. Active participation of stakeholders and local elected bodies in water management should be ensured for its successful implementation and respectable output.

DROUGHT ADAPTED BREEDS OF LIVESTOCK IN ARID REGION

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1. Introduction

The Indian arid zone covers an area of about 32 million ha. The large bulk of the area lies in the arid zone of Rajasthan. Only 38% of the Rajasthan population lives in the 61% area, which forms a part of Great Thar Desert. Livestock population in India is 482.4 million while in Rajasthan it is 49.1 million. Rajasthan has the distinction of having the largest population of cattle, sheep and camel. According to 2003 livestock census, there were 10.8, 10.4, 10.0, 16.8 and 0.5 million cattle, buffalo, sheep, goat and camel, respectively in Rajasthan, while very small increase in cattle population was observed in arid Rajasthan (18.82%) and almost nil in entire Rajasthan (0.83%) as a whole during this period. District-wise population in 2003 of livestock in arid regions of Rajasthan is shown in Table 4.

Despite of large number of livestock population and their production in the state, the per unit productivity of livestock is low due to decreasing grazing area, periodic droughts and erosion in good genetic materials.

Goats are reared both for meat and milk in addition they also provide fiber and manure. One third of the total meat requirement of the country is met out from goat meat. Rajasthan state is also endowed with the best breeds of goat for both milk and meat. The important breeds of goat of Rajasthan are Marwari, Sirohi, Jakhrana and Prabatsar. Some of the goat breeds may yield up to 2 kg milk per day. Marwari, a desert goat breed can survive even on meager quantities of feed, fodder and water.

Milk has attained the status of being as the record largest agricultural commodity next only to rice in the country. At present the milk production in the country is 85.6 million metric tones and is expected to reach 90 million metric tones by 2010 AD. The western part of the state has comparatively lower population of milk animals. This area is more drought-prone and has less fodder to feed the milk animals. However, the best milk breeds of cattle like Tharparkar are found in Jodhpur, Jaisalmer and part of Pali district; Rathi in Bikaner district and Kankrej (Sanchori) in Barmer and Jalore districts of western part of the state.

Sheep and goats have been indiscriminate as the creature of desert conditions because of their close selective and voracious eating habits and to travel over long distances in search of fodder and water. They consume many weeds and bushes. The principle source of meat in the country is from sheep and goats. About 40% of these are slaughtered every year.

2. Importance of livestock farming

The arid region is the home tract of Tharparkar, Kankrej and Rathi breed of cattle. These breeds are recognised for their milk production and efficiency. The Nagauri bullocks are well known as draught animals. Murrah, Mehsana, Jaffarabadi and Surti breeds belonging to arid and semi arid regions are very good milk producers. Chokla, the medium fine wool breed is found in arid region. Nali, Lohi, Magra, Marwari, Jaisalmeri and Pugal, which are major carpet wool producers, also belong to this region. Sonadi and Malpura are good meat producers. Bikaneri, Jaisalmeri and Marwari camels are inhabitants of this tract. Marwari and Kadiawari horses are among the best race horses of the country.

2.1 Livestock farming in drought proofing

Due importance has not been given to livestock farming in the past. There had been more emphasis on crop farming. Agriculture is more affected by drought as compared to the livestock. Under drought years agriculture production may reach as low as 10 % of the normal year, where as production may still remain more than 50 per cent under same conditions from livestock. In a year with less than 25% of average rainfall as much as 20 % of the livestock are wiped out and in a year with less than 50% rainfall the livestock population is reduced by about 10 % in arid region. Livestock farming has, therefore, been recognized as an instrument of drought proofing. The major components of Drought Prone Area Programme are sheep and goat development for wool, mutton and dairy development.

Livestock farming contributes significantly to the economy of the arid region but because of management needs it involves much more intensive use of labor as compared to crop farming. Dairy enterprises in turn involve more intensive use of labor as compared to sheep and goat rearing. On an average 5.5 man hours per household per day during monsoon are utilized in dairying and only 1 man-hour is utilized per adult cow unit. Therefore, at the present level of production with cattle and cow unit, dairy alone provides employment of 10 million man-hours per day. An equivalent amount of employment is estimated to be available from sheep, goat and camel farming. The goat dairying is affected to a lesser degree than cattle dairying during droughts particularly when the land is affected by salinity and wind erosion.

2.2. Breeding livestock for drought prone areas

The state produces about 5% fine, 60% medium and 35% coarse quality wool and as a consequence majority of fine wool for apparels is imported. With a view to improve the breed of sheep and also to increase productivity per animal large scale crossbreeding programmes were launched. The state has 3 departmental sheep breeding farms where half-breds are produced by crossbreeding native sheep with imported improved germ plasm. These half-breds are distributed among shepherds for breeding purposes. As a consequence quarter breds are produced which produce finer quality of wool as well as higher production of wool per crossbred sheep. This programme is under implementation in 12 districts of the state namely Jaipur, Ajmer, Udaipur, Bhilwaxa, Tonk, Chittorgarh, Banswara, Churn, Jhunjhunu, Sikar and Doongarpur.

3. Importance of livestock in mitigating drought

The Livestock is a vital sector of India's agrarian economy, more particularly the rural economy. It generates potential for self-employment. The livestock rearing activity also provides subsidiary occupation to a large section of society particularly to the people living in the drought prone/rainfed areas where crop production on its own may not be very productive and engaging them fully or partially. The main assets of desert landowners are large herds of livestock. In absence of favourable condition for agriculture, livestock rearing is the only alternative source of livelihood for majority of the rural population in arid zone. Animal husbandry has been and continues to be the main stay of most of the inhabitants. The livestock to some extent absorbs the losses in crop production due to weather induced uncertainties. The contribution of the livestock sector in national economy can be assessed from the fact that the gross value of output from livestock sector alone, at current prices of 1998 was about Rs 827 billion in 1995-96 which was equal to about 26% of the value of total output from the agricultural sector. This excludes the contribution of animal draught power.

In Jamnagar district, total livestock population was 0.852 million in 1992, which comprised of cattle (39%), buffaloes (16%), sheep and goats (44%). The Livestock density (ACU km^{-2}) in 1991 was 52. The grazing pressure was 700 ACU per 100 ha of grazing land. During 1977-82 cattle increased by 11, buffaloes by 76 and sheep and goats by 35%. Cattle and buffaloes together were more in hilly/upland, coastal and colluvial plain. Sheep were mostly restricted to coastal and goats in colluvial landforms. In hilly/upland and alluvial plains, buffaloes contributed 68 and 50% of total milk production. In coastal and colluvial plains the share of cows was 36 and 27%. Intense heat and lack of water are two major constraints faced by the livestock in arid region, which restrict expression of their full genetic potential. The livestock may receive some care, but it may not be possible to convert the harsh environment to hospitable one, because these animals have to graze or browse in open fields on an average for 10 hr day^{-1}. It is during this time that animals are exposed to very high temperature.

3.1 Cattle

In the arid region of Rajasthan, there are some important dairy (Tharparkar, Rathi, Red Sindhi), draft (Nagauri) and dual-purpose (Kankarej) breeds of cattle. The Hariana breed of cattle is common in the arid part of Haryana and Gir breed of cattle is commonly found in arid part of Gujarat. On an average, the milk yield per lactation (305 days) of Gir, Hariana, Kankarej, Nagauri, Rathi and Tharparkar breeds has been reported to be 2500, 2000, 2000, 1000, 2500 and 2500 litres, respectively. Livestock rearing is an important occupation of the farmers of the arid areas particularly for augmentation of their income during drought. During 1956-97, the livestock population increased in arid Rajasthan from 13.4 million to 28.6 million. During this period there has been an increase in buffaloes, sheep, goats and camel population by 188.2, 93.2, 94.2 and 52.2%, respectively. Livestock of the arid areas is known to inherent high production potential and drought hardiness. Cows of Tharparkar, Rathi, Gir and Kankraej breeds have high milk production capacity (1,500-2,500 litres per lactation) and Nagauri, Hariana and Kankrej bullocks have reputation as excellent draught animals.

● *Tharparkar*: Once common in most parts of the country, the Tharparkar pure blood is rare now. Good specimens of the Tharparkar breed of cattle are rarely seen even in Jodhpur and Jaisalmer districts once considered to be the home of this breed. A detailed survey has shown that the advantage of crossbred cows over pure Tharparkar, are greatly disturbed by the susceptibility of the crossbred to heat, their high cost of management and health cover. Tharparkar breed of cattle is well adapted to arid environmental stresses. The heat tolerance co-efficient value (88.88 ±1.92) of free grazing animals of this breed was equal to animals of Rathi breed (89.87 ±. 2.51). During summer season, there was an increase in pulse and respiration rates. These parameters were found to be the highest in June and lowest in January. The daily water consumption per 100 kg live weight was also highest (13.27 litre) during May and lowest (5.62 litre) during December. The studies on the effect of improved management on the productivity of Tharparkar cattle showed that the productivity of Tharparkar cattle in terms of lactation milk yield, lactation length, dry period, inter-calving interval, milk fat, solids not fat (SNF) and total solids (TS) was better in cows maintained under scientific management, than those under traditional management (Patel *et al.* 1994). The average lactation yield under improved management was 1,606 kg in a lactation of 293 days. The average peak yield was 9.67 kg in a day. The age at first calving was less than 3 years, which is similar to that of crossbreed cattle in India. Average calving interval and dry period were 364 and 76 days, respectively. No adverse effect of summer stress on the fertility was observed, as 80% cows conceived between April and August. The milk composition of Tharparkar cows was influenced by season. The highest milk fat content was found in winter season, followed by autumn, rainy and summer seasons. However, no seasonal effect was observed on milk fat under arid conditions (Patel *et al.* 1997).

● *Rathi*: Rathi cattle are native of Bikaner region. This breed is a milch type, brown in colour and of large size. A small herd of Rathi cattle was maintained at Regional Research Station of CAZRI for studying its productive, reproductive and adaptability performance under improved management in its native tract. The Rathi cattle attained highest (322.9 ±13.17 kg) and lowest body weight in October and August (246.31±1.90 kg), respectively. They attain puberty when they attain weight between 208 and 302 kg. During pregnancy, animals gained around 53 kg in body weight. Animals started losing body weight after calving and it continued till 90 days after parturation (Kaushish *et al.* 1998).

● *Kankrej*: Kankrej breed of cattle is commonly found in Barmer and Jalore districts of western Rajasthan. Cows of this breed have excellent milk-production capacity (1,500-2,500 litre per lactation), and bullocks are excellent draught animals. Studies were conducted at Bikaner with a herd of 16 heifers and one male calf of Kankrej breed of cattle on traditional management prevalent in rural areas. Animals were maintained on *Lasiurus sindicus*-dominated pasture at a stocking rate of 1 animal per 1.5 ha. During lean period in addition to grazing, animals were given pelleted concentrate mixture and *Lasiurus* grass hay. During 18 months, average body weight gain per animal was 67 kg. Up to the age of 4.5 years, none of the heifers exhibited signs of oestrus.

The male calves also did not show any symptoms of maturity up to the age of 4-5 years in spite of their company with the heifers all the time. It may be concluded that the growing Kankrej heifers must get adequate nutrition to mature at an early age (CAZRI 1991).

3.2 Buffaloes

The buffaloes mostly found in Rajasthan are of the Murrah and Mehsana type breeds found in the northern and southern parts of the desert, respectively. These buffaloes, on an average, yield 3000 litre of milk per lactation period of 305 days. Buffaloes like to wallow in water. Earlier it was thought that these do not adapt to hot arid climate. During the past 40 years buffalo population of Rajasthan increased from 3.0 to 7.7 million. In arid-districts of Rajasthan there were 0.722 million buffaloes in 1951 and these increased to 2.297 million in 1992. People have developed liking for buffalo milk (Kaushish *et al.* 1998).

● ***Buffaloes in rural and urban areas*:** The age at first calving in buffaloes of rural sector averaged 55 months in comparison to an average 48 months in urban sector. The service period ranged from 10 to 12 months in rural areas and 2.5 to 8 months in urban areas. The intercalving periods were 20-22 months in villages as compared with 13-20 months in Bikaner city. Although the incidences of silent oestrous/anoestrus were observed in buffaloes of both the places, these incidences were significantly higher in rural sector. Incidences of repeat breeding were as high as 50-60% in buffaloes managed in villages and as low as 10-20% in buffaloes managed in city. This study indicated that scope for rearing buffaloes in urban areas of arid region is far better than rural areas.

3.3 Sheep

India ranks fifth among the sheep rearing countries in terms of numbers but occupies tenth position in wool production. Average per head per annum wool production of our sheep is 0.88 kg but varies from 4.0-5.0 kg in some advanced countries. The important breeds of sheep in the desert region and their wool production per year are Chokla (1.54 kg), Magra (1.80 kg), Marwari (1.38 kg), Nali (2.12 kg), Pugal (1.67 kg) and Jaisalmeri (1.65 kg). On an average, 1.56 kg of wool per sheep per year is obtained in desert districts which is higher than the average wool obtained from other parts of the state (1.38 kg) and the country (0.88 kg). Sheep rearing in our country is in the hands of the poor people, who occupy very low status in the society. Low income from the poor strains of sheep, unorganised markets for the produce and poor quality pastures also contribute to loose interest in the sheep rearing. Shepherds follow age-old practices of sheep management, which not only affects the capacity to produce but also reduces the productive life span of the sheep (Kaushish 1991, Kaushish *et. al.,* 2006).

About 51 % of the total sheep population of this country is found in southern plateau. Half of the sheep in this region, especially in the coastal areas, produce no wool and rest produce extremely coarse, hairy and coloured fleece. Similar is the quality of wool in the breeds of sheep in the eastern region. Except for Bennur and Nilgiri, they are hairy. These two are only carpet wool producing breeds of this region. The sheep of this area are mainly reared for meat production. Indian sheep are well known as superior carpet wool producers. The best carpet-wool producing animals are found in the northwestern arid and semi-arid parts of India. In the northwestern arid region approximately 23 million kg wool is produced annually. The total wool production in temperate Himalayan region, Deccan plateau and from eastern region is 3.0, 7.2 and 1.4 million kg, respectively. These breeds except Malpura, Sonadi, Muzaffarnagari and Jalauni, produce medium to fine carpet wool. Marwari in northwest and Bellary/Deccani in the south comprise the most popular breeds (Kaushish 1992).

● ***Physiological investigations on heat and water stresses***

Availability of drinking water being the most critical limiting factor for survival in the desert, a detailed comparative study of the physiological responses of different desert sheep breeds to imposed heat and water stress has been made. These studies have pointed out the unusual ability of the desert breed (e.g. Marwari) to maintain circulation even when faced with considerable haemo-concentration. When water intake was reduced to below 75% of the normal daily requirement, there was a steady decline in the body water stores. On an average, there was 18% loss in body weight in all the breeds after remaining without water for 3 days during winter and 25% during summer. Interestingly, the digestibility of crude fibres increased in water restricted sheep while nitrogen balance does not seem to be affected due to water stress. The rate of passage of feed is slow in water-restricted sheep as compared to normally hydrated. The desert sheep apparently relies on reduced urine and faecal water output as the means for combating water stress. This, along with their ability to derive sustenance from poor quality forages helps in maintaining animal productivity in this region. Studies conducted at CAZRI show the physiological superiority of the Marwari breed of sheep over the other breeds studied in maintaining productivity under desert conditions. Prolonged intermittent (twice weekly) watering had no adverse effect on animal production in terms of body weight, wool growth and lambing performance of ewes of the Marwari and Magra breeds. Water restricted (watered twice weekly) animals of both the breeds consumed less than half the quantity of water consumed by the daily watered groups. Thus, with a flock of 100 adult sheep, about 6,500 liter of drinking water could be saved per month by resorting to a twice in a week watering schedule. The daily watering of sheep would, therefore, appear to be a dispensable practice at least in the management of desert adapted breeds.

In one study one group each of Marwari goats and Marwari sheep was watered every 5th day and the other group was watered *ad lib* daily. The sheep and goats of group one lost 7 % and 4 % weight, whereas, body loss was 10 % and 18 % in respective breed between November and March, The sheep and goats of group one consumed water at the rate of 3.4% and % of their body weight per day, while the sheep and goats of second group consumed water at the rate of 8.5 % and 9.2% of their body weight per day, respectively. Blood haemoglobin, PCV (%), total plasma proteins, albumin, globulin, A/G ratio, inorganic phosphorus, and urea; and urine electrolytes like Na, K have remained near normal in sheep and goats of first group. The wool and hair production also in this group did not change. No difference was observed in wool and hair yield in the two groups showing the utility (conservation of water) of watering every fifth day.

- *Responses of shorn and unshorn sheep to heat exposure*

Respiration rate of shorn animals was generally higher in the morning and afternoon. During hot period reverse trend was observed, as it was higher in unshorn animals. Rectal temperature was 38.9°C in the morning and increased to 40.2°C during noon followed by slight decline to 39.8°C in the afternoon. The skin temperature of the shorn animals was generally higher than their unshorn counterparts and the differences were marked during noon. During peak hot period although the respiration rate of unshorn animals was higher than the shorn counterparts, but their rectal temperature was lower indicating better heat tolerance (Kaushish *et al.* 1995).

- *Responses of sheep to solar exposure*

In one experiment hoggets of native Nali, Chokla and their crosses with Rambouillet and Soviet Merino were used to study the effect of solar exposure. Three animals from each breed were maintained both in shade and sun during summer. After first recording, the animals of sun and shade groups were exchanged and the observations were continued. The respiration rate, rectal temperature, skin temperature and fleece temperature at 1 and 2 cm above the skin were higher in the solar exposed group as compared to the animals maintained in shed and higher at 16 and 13 hr than at 9 hr. In general the rectal temperature of the crossbred animals was lower than the native (lower in Merino x Nali); and highest in Nali. It was concluded that the animals maintained under hot sun experienced greater stress as compared to the animals under shade. It also appeared that in crossbreds the thermolytic mechanism was activated at a lower ambient temperature resulting in their higher respiration rate and lower rectal temperature (Kaushish *et al.* 1998).

3.4 Goats

The important goat breeds of arid Rajasthan are Marwari, Parbatsar, Jhakrana, Sirohi and Shekhawati. Mehsana and Kachchhi breeds are found in the arid region of Gujarat. The goats are primarily raised for meat purpose. The Parbatsar and Jhakrana breeds are known for their reasonably good milk and meat production. Marwari doe on an average yields 84 litre of milk in 180 days lactation period, whereas Parbatsar doe may yield up to 132 litre in 170 days lactation period (Patel *et al.* 1999). The goat is extremely well adapted to the arid environment. It grows faster, breeds more efficiently, can tolerate higher salt loads, needs less water and has liking for a wider variety of feeds including many weeds, as compared to the sheep. The fact that the goat is mainly a browser and the sheep a grazer indicates a relevant role of the former in the desert ecosystem. The goat is not necessarily the most important biotic factor involved in desertification. The deep-rooted bias against the goat may not be wholly justified on scientific grounds and its proper place in the agro-system of the desert needs to be redefined, particularly in view of the goat's potentialities to meet the protein gap in the country. The studies on productivity and adaptability of various goat breeds (e.g. Marwari, Parbatsar, Shekhawati, Jhakrana, Kutchhi, Barbari and Jamunapari) under desert conditions showed that these breeds were non seasonal in their reproductive behavior. The incidences of oestrus were very low in case of Jhakrana and Jamunapari goats (Mathur and Mittal 1990).

- *Water use economy in desert goats*

When maintained under intermittent or partial watering schedules after the monsoon till the next summer, the desert goats usually gain in body weight. The percentage increases in body weight of normally watered and 75% water-restricted desert goats over a 10-month period were almost similar (58-59%), whereas there was a decline in the percentage increase (47.47) in body weight in animals watered on every fourth day. Thus, an estimated 235 goats may be maintained if watered every fourth day on the water ration of 100 daily watered animals. The Marwari breed of desert goats has shown maximum economy in water use in comparison to other types of animals examined.

- *Effect of supplementation on productivity of desert goats*

Under existing small ruminant production system the slaughter weight of lambs and kids in the country is lower and age at which it is usually achieved is much higher. The system of raising finisher lambs and kids for meat purpose under grazing with diet supplementation, is cost effective for the producer and has not been largely adopted by the farmers owing to their poor economic background and restricting to their age-old traditional practices. The experiment conducted in the country on performance of sheep or goats under grazing with supplementation has been periodically reviewed (Patanayak and Singh 1972, Patnayak and Mohan 1974, Patnayak 1993, Karim 1995 and Karim *et al.* 1996). The experiment results indicated that in addition to free grazing on rangeland, limited amount of concentrate supplementaion (1.5 to 2.0 % of body weight) would provide 25 and 30 kg finishing weight at 6 and 9 months of age, respectively. Grazing with supplementation on established pasture has potential of still higher production traits. The established *Cenchrus* pasture stocked as per carrying capacity with concentrate supplementation 1.5 % of body weight provided 27.3 and 26.2 kg finishing weight in lambs and kids at 6 months of age, respectively (Shinde *et al.* 1995). However, grazing with *ad libitum* concentrate supplementation had no added advantage in the kids as they achieved 25 kg at 6 months and 30 kg at 9 months of age even under regulated level concentrate supplementation.

4.0. Livestock shelter management

Although the livestock breeds of arid regions are well adapted against the desert vagaries, their production potential is also undeniably influenced by the harsh environmental conditions of the region. Extremes in the climate conditions can have enormous effects on the productivity of farm animals (Burke 1998). The main aim of the shelter is to provide comfort and a sense of well being to animals so that they can produce to their maximum genetic potential. However, in most parts of the Indian arid zone, shelter is not generally provided to the small ruminants whereas, thatched roof shelter is common for large ruminants. A survey revealed that in arid western Rajasthan, 80% farmers provide thatched houses for large ruminants (cattle and buffaloes), while only 10% farmers provide thatched houses for small ruminants. The facilities of minimum shelter were found with majority of the farmers, but they prefer to keep their animals outside the animal house during normal climatic conditions of every season. In most of the surveyed area, East-West orientation was observed in arid shelters, but in some cases orientation of shelter was also observed to be of North-South direction to protect animals from cold winds from North during winter season. This survey revealed the use of various types of local materials for the construction of thatched roof, wall and other parts of the houses. Most of these materials consisted of basically branches, twigs of shrubs and trees available in abundance in arid region. In Jodhpur and Nagaur districts, thatched roof was usually constructed with *Khimp* (*Leptadenia pyrotechnia*) and *Shinio* (*Crotalaria burhia*), while *Bui* (*Aerva pseudotomentosa*) was mainly used in Barmer district. The twigs of bushes such as *Aak* (*Calotropis procera*), *Bordi* (*Ziziphus nummularia*) and *Vilayati Babul* (*Prosopis juliflora*) were used to prepare side-wall of the houses (Table 5).

Table 1. List of local plant materials used for making thatch houses for livestock

Plant Material	Utility area
Aak (*Calotropis procera*)	Used in manufacturing the side walls and roof
Bui (*Aerva pseudotomentosa*)	Used in thatched roof manufacture
Bordi (*Zizyphus nummularia*)	Used for preparation of thatched roof and side walls
Vilayati Babul (*Prosopis juliflora*)	Used for preparation of thatched roof
Khimp (*Leptadenia pyrotechnia*)	Used for preparation of thatched roof
Shinio (*Crotalaria burhia*)	Used for preparation of thatched roof

Three types of housing systems are found in Rajasthan for control of microenvironment:

1. Open housing system developed by simple covering of open space near tree with throny bushes and fenced wire.
2. Thatched housing system in which the closed space is surrounded by stone slabs with thatched roof, which is prepared by local plant materials like *khimp* (*Leptadenia pyrotechnica*).
3. It consists of proper *pucca* (bricked) house made up of thick stonewalls and stone slab roof. An open space is also kept in this model for free movement of the animals

The diurnal variation in rectal temperature, respiration rate and skin temperature were observed in all seasons under different housing systems. Interestingly, the higher rectal temperature of Marwari goats was recorded in afternoon hours in winter season in comparison to other hot dry and hot wet seasons. This indicates that the black coat colour of Marwari goats absorbs more heat in sunlight during winter season to keep their body warm. The effect of housing system was not significant on rectal temperature of Marwari goats in morning hours however; it was higher in afternoon in open housing system in all seasons as compared to other two systems mentioned above. It is perhaps due to the reason that microclimate of all housing systems was same as outside climatic in morning hours but in afternoon hours the microclimate of *pucca* and thatched houses was better than open housing system due to the complete shade in closed area. Similarly, the respiration rate and skin temperature were higher in goats of open housing systems during late hours during dry and wet summer season (March to October) in comparison to other two systems, where due to shade the effect was not so high in afternoon hours. The effect of shelter was also observed on milk production in Marwari goats (Table 6). The lactations of these goats started in the months of September and October, since the kidding took place in these months and lactation was almost completed by April. So, the effect of winter is pronounced on the lactation period of the goats in comparison to summer months. The data on 90-days lactation yield, total lactation yield, lactation length and milk fat and SNF revealed that the lower milk yield with low fat contents was observed in goats housed without shelter, while the higher lactation milk yield with higher fat contents was found in the goats housed in *pucca* housing system.

Table 2. Milk yield of Marwari goats under different housing systems.

Housing system	90-days milk yield (liter)	Total lactation yield (liter)	Lactation length (days)	Fat (%)	SNF (%)
Open	55.3 ± 5.3	76.5± 9.6	148.6± 15.2	3.04±0.14	7.89±0.08
Thatched	61.1±4.1	83.8± 10.3	126.3± 11.1	3.41± 0.12	7.97± 0.09
Pucca	62.8± 6.6	91.7± 14.0	143.8± 13.8	3.46± 0.11	8.12± 0.09

However, the performance of goats, which were kept in thatched housing system, was found moderate in terms of milk production. The reasons for higher milk in *pucca* housing system were due to complete protection of goats from chill winds in night hours of winter seasons. This protection mechanism was not appropriate in other two housing systems. The behavioural changes were also observed in goats during early morning hours of peak cool days, when minimum temperature was recorded to 8 ^{0}C with chilled winds from north direction. The goats showed shelter-seeking behaviour in open housing system. Animals reduced the body surface area with erected coat hair; and huddling was observed. While, the goats of thatched and *pucca* housing systems were found inside the closed area of the shelter. The low atmospheric temperature alongwith chilled wind affected the productivity at greater extent because wind increases the loss of body heat from the surface of an animal. Although, the livestock breeds of arid region are resistant to high and low environmental temperatures, but they do suffer from extremes of hot and cold seasons, when exposed to upper and below critical temperatures. Tree shade has been found to be common available shelter to the livestock, with its limitations. Closed type shelter with open space for free movement for livestock, has been found to be most suitable animal shelter in arid zone

5.0 Some technologies / tools for improving livestock production during drought

- **Drinking water sechdules for livestock:** Water is a scarce commodity in arid region; the problem has become more acute during last 25 years. Studies conducted revealed that desert sheep can be kept on twice weekly watering schedule for their entire life without any apparent ill effect on their production. Meat goats in this region can also be kept on this water schedule. However, the thrice a week watering is optimum for satisfactory milk production in milch goats. By adopting this schedule at least 50% of water can be saved. Salinity in underground waters is the common occurrence in desert region. It is clear from 10 years in depth studies that desert sheep and goats can be reared on moderately saline waters containing 5 g l^{-1} of dissolved salts for prolonged period of time without any adverse effect on any production parameters.

- **Improving low quality fodder with urea treatment:** As such wheat straw is a very poor quality fodder because of its low palatability, digestibility, protein (CP 0.5%) and mineral contents along with poor intake. Efforts are being made for improving its nutritive values. Fodder enrichment with urea at 4% level increases CP value by 8% and simultaneously significantly increases its palatability and digestibility.

- **Economical feeding of cattle utilizing cheaper non conventional - *tumba* seed cake:** The cattle feed having 25% *tumba (Citrullus colocynthis)* seed cake has no adverse effect on the productive and reproductive performance of Tharparkar cattle(Mathur 2004). It is locally available in abundance (having 16-20% CP) and is a cheaper source of protein and is normally used as a fuel for furnaces and thus wasted. Monetarily it may save around 18-20% of cost without impairing the productivity. *Tumba*-seed cake is produced in large quantities annually. The oil is also extracted from it at most of the district headquarters of the state.

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MANAGEMENT OF SHELTER FOR AMELIORATION OF ENVIRONMENT STRESS FOR OPTIMUM PRODUCTION

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Introduction

The arid region is characterized by low and erratic rainfall, high wind velocity, high temperature and evapotranspiration. Extreme high temperature (48.0 ^{0}C) in summer and very low temperature (0.0 ^{0}C) in winter for certain period of day are common in desert climate. These desertic conditions cause both nutritional and environmental stress to the livestock of this region. Though the livestock of this region are well adapted to the desert vagaries but extremes of the climate can have adverse effect on farm animals (Bruke, 1998). Protection of animals against extremes environmental condition is also a very important component of modern management system, as to the intensive system of animal rearing is being adopted increasingly, especially in the context of shrinking grass lands and intensification and commercialation of animal husbandry to fulfill the ever increasing human needs. The main of the shelter is to provide comfort and a sense of well being to animals so that they can produce to their genetic potential.

Shelter management practice in arid zone

Depending upon the resource availability and socio-economic conditions of the animal rearing or farmers, three systems production are practiced in arid western part of Rajasthan. Extensive, in which the flock/ herd grazes over a large areas of marginal land unsuited to agriculture. The flock is usually shut into a yard at night in open enclosures mainly to protect animals from predation. Second system is subsistence, in which a few animals are tethered during the day and put into a protective shelter (Semi-open type)at night . Third one system is intensive, in which the animals are confined to yards and shelters and feed is brought to the flock. This system offers the greatest protection for the flock from both predators and parasites. Although it may make the best use of limited land recourses, this system is also increase labour and capital investment required for facilities.

It was revealed from the study that 80 % farmers provided "Thatched roof type shelter" to the cattle and buffaloes and only 10 % farmers provided such type shelter to the small ruminants. Most of the animal houses in rectangular shape but few of them were in round shape. Almost all animal houses are having soil floor, pucca floor was only found in commercial production system near cities area The local materials which were used to construct the animal shed are basically non edible parts of grasses, shrubs and trees etc., freely available in the villages. Feed manger was found in almost all animal shelter, but the water trough was found only 20% in animal houses because most of the animals in the villages drink water from a common water body. No proper attention for animal shelter was given, low cost or without cost local materials are only used to construct the animal houses. Farmers are more concerned for animal housing during winter season than other seasons. Three types of shelters for livestock were observed in the rural areas of the arid zone, viz; open housing system (Barbed enclosure without any roof), Kutcha (Thatched roof house) and Pucca (a closed type pucca house).

Environment stress and production performance of the animals

Harsh environment conditions either extreme high or extreme low temperature is a major characteristic of arid areas, high range of fluctuation in environment temperature within season and between season caused loss of productivity in animals. Livestock are homeotherms, that is, they must keep their body temperature within a moderately narrow range to work efficiently. To do this they maintain a thermal balance between the heat they generate or gain from the environment and the heat they lose to it. This generates heat, which has to be dissipated to the environment by the process of conduction, convection, radiation and evaporation. (it's the net effect of these processes which is important, although forced convection in a cool climate may be dominant. Over a limited range of environments, 'thermoneutral zone' is a zone where the balance between heat production and environmental demand is achieved. Within this zone, the animal is not stressed in achieving a balance. Beyond the 'thermoneutral zone' an animal becomes subject to 'stress' and its productive efficiency is decreased in terms of meat, milk eggs produced per unit of food intake. It is well established that stress has a profound effect on the biology of an animal and the out come of high stress systems is reduced productive efficiency. The principal effects of acute or chronic stress are on the endocrine system, the immune system and as the central nervous systems (CNS) and these are associated with profound changes in the animal's behaviour. All these adaptations are components of the overall attempts by the animal to maintain homeostasis in a rapidly changing environment.

Milk production: The optimum environment temperature for lactation is dependent on the species, breed and degree of tolerance to heat or cold. Holstein cows declines their milk yield at 21 C and Brown Swiss and Jersey declines at about 24 to 27 C, whereas, milk yield of Zebu cattle declines only above 34 C. Dutta et. al. (1995) observed that temperature and humidity together explained 62.7 % of variation in milk yield/cow/ day. Higher lactation yield was observed in buffaloes which calved during winter season (Patel and Tripathi, 1998). Similarly, Tharparkar cows calved during winter season (1439 lit) produced more lactation yield in comparison to summer (1275 lit) in a period of 305-days (Patel, et.al.,2000). The milk fat content of Tharparkar cows was found higher in autumn and winter season (October to February) and lower in both hot dry and hot humid seasons (March to September) in arid zone (Patel et.al., 1994). Proper shelter leads to increase milk yield in both hot and cold stress conditions. Higher lactation yield (133.2 lit) was observed in Marwari goats which was kept under closed type pacca housing system during winter season, while the goats of open housing system (without shelter) produced only 92.4 lit milk in lactation in arid zone (Patel et.al., 2001).Goats of pacca housing system also produced higher fat % in milk (4.47%) than open housing system (3.41%).In a another study when two shelter systems i.e. loose housing system (I) and modified shelter (II) was compared , it was concluded that higher milk yield was produced by cows of IInd group indicating that providing protection from the high ambient temperature could augment the milk production pf lactating cows (Mahendra Singh, et.al., 2003).

Reproductive efficiency: Reproductive performance of an animalis mainly influenced by heat stress, as the conception rate has been reported to be significantly reduced in summer from 5 to 20% in Israel due to poor oestrous behaviour (Flamenbaum, 1998). The reproductive behavior of buffaloes is significantly influenced by climatic condition. Bhattacharya *et. al.,* (1970) observed detrimental effects of environment heat on reproductive efficiency in buffaloes. Luktuke *et. al.,* (1973) found that buffalo ovaries were least active during extremes of climatic conditions. Conception rate is highest during the cool season (Oct to Jan) and lowest during the hot and dry season (May to July). Provision of water splashing on Murrah buffalo bulls coupled with artificial aeration during hot humid season could improve the physical attribute of the semen viz. volume, mass activity and sperm concentration (Pawan Singh et al, 2000). Shorter day length did not affect the conception rates. Winter months were most favorable for conception. On the other hand it was also observed that buffaloes calved in rainy season had higher reproductive efficiency in terms of lower service period and calving interval (Patel and Tripathi, 1998).

Improved Animal Shelter (IAS) for goats

This was observed from the studies conducted on various type of housing systems that a close type housing system with open space was better for both hot and cold weather conditions of the arid zone in comparison to traditional animal housing system i.e. thatched roof semi-open type animal shelter. An improved animal shelter was designed and developed based on the study of different factors like orientation, wind direction, sun movement, air temperature, local materials for construction etc. (Fig-1). Improved animal shelter consists of angle iron frame, asbestos sheet and stone slabs. Heavy duty angle iron (50x50x6mm) frame was fabricated and fixed on the ground by grouting. Seven heavy duty trusses were also fabricated and fixed at ten feet interval for proper distribution of asbestos roof load.

The orientation of the shelter was kept east-west direction; the long axis of shelter is 60 ft which is open from south direction and north direction. Hence, this orientation with generous provision for ventilation / air movement to help dry up threshold will be most suitable. Furthermore, the south facing shelter has the advantage of receiving larger solar radiation during winters than during summer. Small over hang on south faced can cut off direct solar radiation during summer and allow it during winter. It also gives protection from rains. The open space of north axis was covered by plastic curtain to minimise the entry of cold winds inside the shelter during winter.

The double slope roof of the shelter was made by corrugated asbestos cement sheets (1x3mtrs.) on angle iron frame. The roof height is 10 feet from centre and 7 feet from sides. 4 inch thick thatch panels were fixed just below the asbestos sheets to provide insulation. The side walls were erected using stone slabs with 4ft height in north faced and 3ft in south faced. The floor of this shelter is elevated 1ft from the ground and filled with calcified soil to give compactness, which also absorbed the urine and faecal material of the goats.

The feeding manger of 50 ft length was constructed along with the wall of north side of shelter by using stone slabs of this side. The height of manger was kept 1ft 9 inch from the ground level with 9 inch depth and 12 inch width for holding ample feed material. This manger is also facilitated with slanting slope from outer to inner side which helps in sliding of feeding materials while feeding to the goats. A ladder type structure of 1" diameter G.I. Pipe has also been fixed on outside wall of the manger to prevent entry of the goats inside of the manger to avoid the wastage of feed materials. In the same direction a 10ft. long water trough with similar dimensions was also constructed in the corner of the shelter.

Microclimate of Improved Animal Shelter

Higher minimum temperature was recorded in Improved Animal Shelter (IAS) during winter from October to March ranging from 12.7 to 21.6°C. Higher value of minimum temperature for summer months was also recorded in Improved Animal Shelter from April to September, which ranged from 23.3°C in April to 28.20°C in June. Whereas, comparative lower values of minimum temperature were recorded in Traditional Animal Shelter (TAS) round the year. The difference of minimum temperature between IAS and TAS was more (1.42° C) during winter and less in (0.35°C) in summer months. The maximum temperature in IAS was found lower during summer months from March to September in comparison to TAS, while only in the month of July maximum temperature was almost equal in both animal shelters may be due to rainy season and higher level of moisture in air. However, during winter months i.e. November to February, the values of maximum temperature in IAS were found higher than TAS.

In IAS, the higher value of minimum temperature was mainly due to the absence of direct entry of air temperature inside close type animal house, secondly the minimum temperature which was attained usually in absence of thermal radiation during the time beyond midnight, remained higher in closed type animal shelter, because of inadequacies in loss of absorbed heat and low ventilation also add to this effect. The lower maximum temperature in IAS during summer months, could be due to the failure of direct sunlight to reach inside closed type animal shelter, which prevented the rise of ambient temperature much beyond that in open, whereas the refection radiation in addition to direct radiation caused higher maximum temperature in TAS. The higher level of relative humidity in IAS has been observed, which could be due to low ventilation means and less air flow inside shelter.

Production performance of goats under Improved Animal Shelter

Milk Production Performance

Two groups of Marwari goats were housed in traditional animal shelter (TAS) Group-I which was developed as a simple thatched roof structure and Group-II was housed in Improved Animal Shelter (IAS) after grazing hours. The results of the study showed that despite the better adaptability of Marwari breed to the climate of this region, goats of traditional animal shelter (TAS) produced lower milk yield (129.3 lit.) during lactation than the goats of IAS group, which produced 157.6 lit of milk. The peak yield of this group was also found higher 1.46 lit as compared to 1.38 lit in Group-I. (Table-1). The reason of higher milk production performance in IAS was probably due to complete protection of goats from cold weather in winter season. Whereas, the goats housed in traditional shelter were unprotected due to open type shelter with only simple thatched roof at 10' height. During night in winter, the effective temperature of the outer environment may be very much lower than the absolute air temperature because of increased radiant losses to the night sky. This results in increase in the rate of loss of body heat and therefore, the feed energy requirement is utilized for maintaining the optimum body temperature rather than for the production of milk. On the other hand the provision of proper shelter i.e. closed type with open space, reduces the animal's metabolizable energy requirement. Thus, the energy available with the animal is utilized for production purpose in proper shelter conditions.

Table: (1) Lactation performance of Marwari goats under different housing systems.

Parameters	Traditional Animal Shelter	Improved Animal Shelter
90 -Days Lactation Yield (lit)	64.0±6.2	69.3±5.0
Total Lactation Yield (lit)	129.3±10.1	157.6±20.8
Lactation Length (days)	180.5±17.5	193.0±18.8
Peak Yield (lit)	1.38±0.14	1.46±0.16
Fat (%)	3.42±0.13	3.60±0.10
SNF (%)	8.18±0.10	8.29±0.07
TS (%)	11.69±0.19	11.89±0.18

The kidding of Marwari goats takes place during the period from mid September to December months. The first two winter months October and November are comfortable for the goats from the climate point of view. However in later two to three months i.e. from December to February, animals undergo cold stress especially during night hours due to lowering of the atmospheric temperature and blowing of chilled air (Fig.-1) As per the lactation curve, the lactation performance of goats is on peak in these months. Therefore, the peak lactation of the goats

during winter can be harvested with provision of Improved Animal shelter in the arid region. Keeping this finding, the housing practice ought to be adopted to achieve the optimum milk yield in goats of this arid region

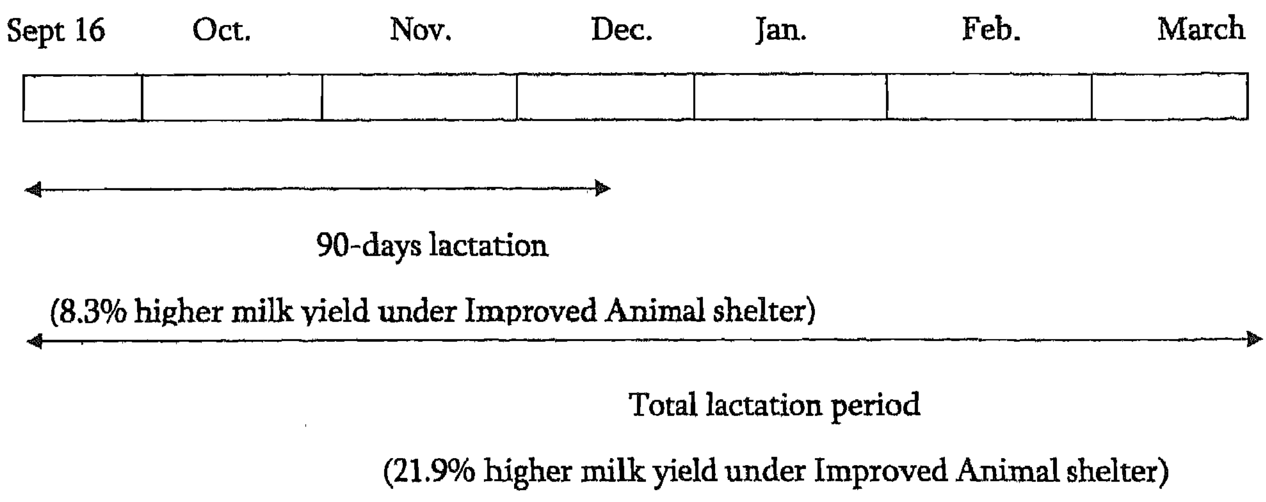

Fig Fig. 1 Lactation period of Marwari goats in a calendar year

Growth performance

Six month old kids of Marwari and Parbatsari breeds (10 from each breed) were divided into two equal groups. Group I animals were maintained under traditional animal shelter (TAS). Whereas, kids of Group II were kept under Improved Animal Shelter (IAS). The lower minimum temperature was observed in TAS, whereas, the lower maximum temperature was observed in IAS during the summer period i.e. May to October months. The micro-climate of TAS was close to macro-environment because it was open from all sides and only roof is covered by thatch, which could provide only shade to the animals.

The kids were kept for six months period of experimentation from May to October, which was hot dry and hot-wet weather. Both the groups were stall fed with 400 gm./day/kid Lentil dry fodder and 200 gm PCF (CP 18%) up to end of June, after which the quantity of fodder given was increased to @ 600 gm/day/kid. These kids were also let out for grazing in closed fenced area of the farm from July onwards. The animals of Group-I was let out after 10 AM for three hours and Group-II was let out in early morning from 7 AM to 10 AM. Water was supplied *ad libitum* to these animals.

Table (2): Water intake (lit) of Male kids in two different housing system during hot months.

Months	Improved Animal Shelter(kid/day)	Traditional Animal Shelter (kid/day)	Difference	Percent Difference
May	1.76	2.18	0.42	23.9
June	1.80	2.45	0.65	36.1
July	1.32	1.60	0.28	21.2
August	1.37	1.41	0.04	2.92
Average	1.56	1.91	0.35	21.03

Table (3): Body weight of male kids under different housing systems during hot season.

Type of shelter/Age	Traditional Animal Shelter		Pucca Animal Shelter	
	Marwari	Parbatsari	Marwari	Parbatsari
6 Months	12.24±1.84	16.60±1.87	12.52±2.06	15.60±2.21
9 Months	14.16±2.14	19.30±1.21	16.24±2.37	20.10±2.18
12 Months	19.76±2.00	24.60±2.46	22.04±2.64	26.45±2.34
Body Weight Gain	7.52±0.60	8.00±0.68	9.52±0.70	10.85±0.43

Higher water intake was observed in kids of Group-I (1.91 lit./day/kid) than the Group-II (1.56 lit/day/kid).The difference between water intake in two groups was more visible during hot dry months in comparison to hot humid months (Table-2). Higher body weight gain was achieved in kids of Group II. The average body weight gained was 10.2 kg. in kids kept under Improved Animal Shelter, whereas 7.8 kg. body weight was increased in kids of Group I (Traditional Animal Shelter) during the experimental period.

When these breeds were compared, higher body weight gain was found in Parbatsari than Marwari kids, but the difference in between two breeds was more visible in IAS group (Fig.-2). Parbatsari kids gained 10.85 kg. body weight and Marwari gain 9.52 kg. in Group II, whereas, body weight gain was more or less similar in both breeds in Group I, which was 7.52 and 8.0 kg. for Marwari and Parbatsari kids, respectively (Table-3)

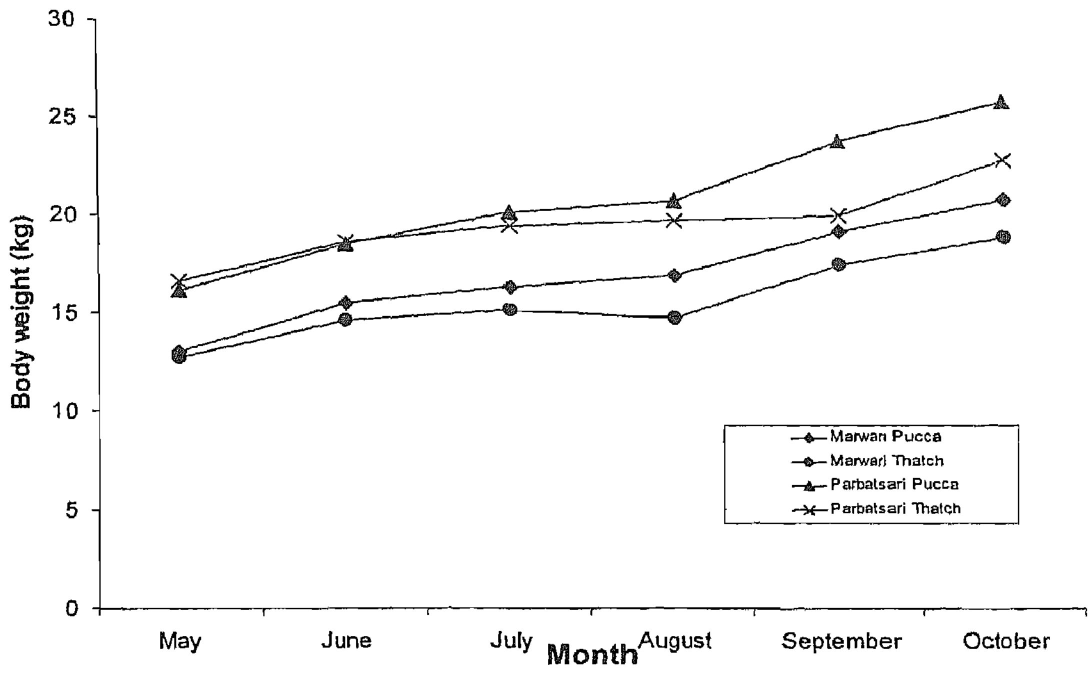

Fig.2 - Body weight gain of male kid under different housing system

Conclusions:

Although, the livestock breeds of arid region are resistant to high and low environmental temperature, but they do suffer from extremes of hot and cold seasons, when exposed to upper and below critical temperature. Tree shed has been found to be common available shelter to the livestock, with its limitations. Closed type shelter with open space for free movement for livestock, has been found to be most suitable animal shelter in arid zone.

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ROLE OF PROBIOTICS IN IMPROVING LIVESTOCK PRODUCTIVITY

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Introduction

There is growing interest in probiotics, applied as therapeutic and preventive agents, such as *Lactobacillus*, *Bifidobacterium*, *Pediccoccus*, *Leuconostoc* and *Enterococcus*; some strains of yeast (*Saccharomyces Candid*) and mould (*Apsergillus oryzae* and *niger*) are used most often in the production of probiotics.

What are Probiotics: Probiotics are defined as viable cell preparations or foods containing viable bacterial cultures or components of bacterial cells that have beneficial effects on the health of the host. Hence, live microorganisms and substrates (sometimes known as prebiotics) that promote growth of indigenous probiotic microorganisms and components of probiotic microorganisms are included.
Probiotics preparations have a beneficial influence on animals, manifested by higher body weight gains, increased activity of saccharase and maltase. These are health enhancing functional food ingredients used therapeutically to prevent diarrhoea, improve lactose tolerance, modulate immunity and antineuoplastic effects. They also have potential to prevent cancer and lower serum cholesterol levels. e.g. *Lactobacillus* and *bifidobacterium* etc. (Akman and Yagci 2002).

Prebiotics: A prebiotic substance has been defined as a non-digestible food ingredient that beneficially affects the host by selectively stimulating the growth and/ or activity of one or a limited number of bacteria in the colon. Therefore, compared to probiotics, which introduce exogenous bacteria into the colonic microflora, a prebiotic aims at stimulating the growth of one or a limited number of the potentially health promoting indigenous micro-organisms, thus modulating the composition of the natural eco-system.

Prebiotics (non-digestible oligosaccharides) can fortify intestinal microflora and stimulate their growth. Non-digestible carbohydrates act as selective prebiotic fermentation substances for beneficial colonic proboitic bacteria to produce short chain fatty acids. These short chain fatty acids elicit effects such as alteration in preneoplastic lesions, enzyme induction, suppression of mutations and binding of potential carcinogens. Prebiotic – Probiotic interaction and activity is therefore key role in colon cancer protection by non-digestible carbohydrates. Further, prebiotics have been found to stimulate absorption of several minerals to improve mineralization of bone by increasing the availability of Ca, Mg, Zn and Iron etc. Effect of prebiotics depend on dose, the time of administration, content of calcium in the diet, the part of skeleton investigated and the age of the concerned studied (Cashman and Tannock 2002).

In other words Probiotics are commonly defined as viable micro-organisms (bacteria or yeast) that exhibit a beneficial effect on the health of the host when ingested. They are used in feeds, especially in fermented dairy products; whereas, Prebiotics are non-digestible foods which improve the growth of bacteria in colon. Intake of prebiotics can significantly modulate the colonic microbial flora by increasing the number of specific bacteria. Non-digestible oligosaccharides in general and fructo-oligosacchaides in particular are prebiotics (Apan, 2000). In short, a probiotic is a live/viable microbial feed supplement; whereas Prebiotic is a non-viable food ingredient selectively metabolised by intestinal species seen as beneficial.

Importance of Probiotics

The health benefit of probiotics have been the subject of increased research interests, these food supplements have been demonstrated to alter the pre-existing intestinal flora so as to provide advantage to the host. The Scientific evidence both for and against their role in promoting health and treating diseases is important, specific attention is turned to their effects on immuno-modulation, lipid metabolism, cancer prevention, diarrhoea, helicobactor pylori, necrotizing, enterocolitis, allergy and inflammatory bowel diseases. A combination of probiotics and prebiotics may be the most effective strategy for maximising anti-carcinogenic effects (Titelbaun and Walker 2002).

Probiotic administration transiently alters the gut micro flora by donating cells to the ecosystem. It may be possible to use carefully formulated products in the alleviation of inflammatory bowel diseases or allergic diseases if the safety of such probiotics can be guaranteed.

In recent years increasing attention has been focussed on the possible beneficial effects of probiotics, such as enhanced resistance to invading pathogens, improved bowel function, anti-colon cancer properties, lipid lowering action, improved calcium bioavailability amongst others. The increased utilisation of bioactive components (pre and probiotics) in the formulation of food products that may have a significant effect on human health, especially on the prevention and treatment of different diseases. Probiotic bacteria are sold mainly in fermented food and dairy products play a predominant role as carriers of probiotics. These foods are well studied for promoting the positive health image of probiotics for several reasons.

Lactobacillus group of organisms are the main type in probiotics and spores of these bacteria are commonly used for this purpose. When fed to animals and poultry, they enhance FCR leading to more production of better quality. Besides, there is a substantial fall of losses due to infection among them. These are given as feed additives or medicaments. These bacteria are mainly responsible for fermentation and they are seen in the fore-stomach of rumen of cattle, sheep and goats. They are needed for cellulose fermentation in it. In addition, they synthesize many vitamins of "B" complex group and also vitamin "K" in the GI tract. They also serve as a source of protein to their hosts after undergoing lysis. Thus, they are beneficial to the body.

These microorganisms can be classified broadly into two groups. The permanent flora that are normally seen in the gut. These are useful ones and are the gut residents. The other group is temporary flora that are seen at times. They stay for sometime only and they exert their effects as they pass through the gut. Moreover, these friendly bacteria can also stimulate the growth and multiplication of the usual resident bacteria of the gut. e.g. a new Bacillus subtilis strain, which is not normally present in the gut, is found to be very effective in promoting growth and other desirable characteristics in animals and poultry when spores of this organism are fed to them. These changes can improve GI function leading to improved health and longevity.

In healthy animals and poultry there is a balance between useful and harmful bacteria in the gut. When this balance is disturbed and when harmful ones take upper hand discomfort or diseases result. Such animals tend to become weak. Their growth rate and production is low or reduced, besides deaths at times. On the other hand, when useful bacteria take upper hand health is promoted. The growth rate and production of these animals are bound to be at their maximum.

Probiotics/bacteria are said to produce some antibiotics like, Acidolin, Acidophylin, Lactin etc. These are highly effective against pathogenic bacteria viz., *Eschrichia coli.* the main harmful bacteria of the stomach and intestines. In addition, these bacteria can also produce certain organic acids like, Formic acid, Lactic acid, Acetic acid etc. and increase intestinal acidity. Thus, the contents of stomach and intestines are not conducive to the growth and multiplication of many pathogenic bacteria. This is not also favourable for coccidian, so very advantageous to chicks. Added to these effects, probiotic bacteria being aerobes lower oxygen tension and render gastro-intestinal canal less prone for the growth and multiplication of pathogenic bacteria that are mostly anaerobic. Hence, the counts of *Lactobacillus* group, the useful bacteria of the gut are increased. Consequently, the counts of *E.coli* and others that are harmful are decreased. Besides, they compete with pathogenic bacteria of the gut for the use of nutrients available in the stomach and intestines. Thus they deprive pathogenic bacteria of their nutrients to some extent.

In stress, the bacteria of the *Lactobacillus* group decreases to a great extent in the GI tract, resulting an increase in the counts of harmful ones leading to impairment of digestion or GI functions. These changes greatly affect health and activity in them. The growth as well as production in animals and poultry is reduced to a marked extent. When the stress is more and prolonged animals become weak and dull. They are more prone to diseases and deaths. There are many types of stress in animals and poultry. e.g. excessive heat, cold, medication with antibiotics or vaccination. Then, it is better to feed them with probiotics. This is natural way of combating diseases. It has been found that when animals are fed with spores of these organisms they recover more easily as well as quickly especially in ailments of GI tract.

Role in livestock production: probiotics as animal growth promoters

The existing nutritional and managemental practices are not sufficient for achieving higher animal productivity. In order to promote growth and to impart flavour to animal feeds additives are incorporated from external sources in the animal feeds. Minerals (Ca, Mg, P, Zn, Cu), vitamins (fat soluble as well as water soluble) and hormones constitute important groups of feed additives. Since a long tine these additives had been used for control of infections. It is believed that use of antibiotics could enhance growth up to 20%. However, some of the antibiotics are not currently in use due to therapeutic purposes and their harmful side effects.

Unchecked and indiscriminate use of antibiotics has had their ill effects and developed resistant microbial strains, which made treatment of infectious diseases difficult. Residual effects of antibiotics led to development of allergy among consumers of animal foods like, milk, meat and other products resulting diarrhoea, enteritis and food poisoning etc. (Moro *et al.* 2002).

In view of above, animal Scientists have been engaged in finding suitable substitute for conventional antibiotics additives. For centuries curd and fermented milk were considered to help in controlling GI problems. Such foods are today regarded as valuable probiotic preparations. Their major advantage is that they are cheaper and don't exert any side effect like development of allergy and microbial resistant.

Probiotics unlike antibiotics facilitates growth of desirable microflora. This microflora in turn modifies the environment of GI tract and results in better utilization of feeds. Important microbes acting as probiotics include : *Lactobacillus spp, acidophilus, Lactobacillu bulgaricus* and *Lactobacillus salivarius* are widely used. Use of these strains is found to promote body weight, modify gut microflora and help in controlling cholesterol levels, some anti-tumour activity also.

Probiotic research has gained substantial momentum in recent years. As a result several types of probiotics have become available as safe growth promoters to livestock owners. The probiotics are now available as gels, pastes, powders, capsules and granules etc. In some cases probiotics could even help remedy of clinical conditions involving GI tract. Probiotics have opened up a new area of study in improving livestock productivity. It is believed that their use would benefit farmers in great measure and help in reducing dependency on antibiotics. Their use will eliminate ill effects of antibiotics and will result in substantial economic gains to the livestock owners. That's why these are also known as "Future antibiotics".

Animal feed additives are used worldwide for many different reasons. Some help to cover the needs of essential nutrients and others to increase growth performance, feed intake and therefore optimises feed utilisation. The health status of animals with a high growth performance is a predominant argument in the choice of feed additives. The consumers more and more question the use of feed additives.

Therefore, the feed industry is highly interested in valuable alternative, which could be accepted by the consumers. Probiotics, prebiotics, enzymes and highly available minerals as well as herbs can be seen as alternatives. Herbs, spices and their extracts (botanicals) have a wide range of activities. They can stimulate feed intake and endogenous secretions or have anti-microbial, coccidiostatic or anthelmintic activity (Wenk 2003).

The animals are constantly exposed to a diversity of health challenges and the gastrointestinal tract is a major site of exposure. The use of antibiotics in animal feed to improve growth is a common feature. The use of probiotics (biotherapeutic agents such as, *lactobascillus*, *bifidobacterium*, *bacillus*, *streptococcus*, *pedicoccus*, *entrococcus*, *saccharomyces*, *aspergillus* and *torulopsis*) in animals in relation to gastrointestinal tract and the immune system are of prime importance.

Probiotics or immune supplements can inhibit pathogenic gut microorganisms or make the animal more resistant to them. The administration of probiotics seems to be promising with regard to their capacity to modulate the bacterial composition in the colon and there are indications that probiotics can beneficially influence colonic metabolism. To recognise the potential advantage of probiotic use, we need to understand how bacterial cells function in the gut ecosystem and how bacterial functions impact on the host.

Research work has been done in different livestock species in our country and in abroad, some of them are being mentioned here as under:-

Swine/Pig

The alternatives to antibiotics as growth promoters in pig nutrition like probiotics or a combination (of both probiotics and prebiotics i.e. synbiotics) are the research interests today. Pairing non-digestible-oligosacchairdes (NDO) and probiotics strains that have the metabolic potential of fermenting the supplied NDO at a competitive rate compared to the indigenous microflrora is likely to be a successful strategy in controlling the intestinal ecosystem. The expected benefits are in improved survival rate during the passage of the probiotic bacteria through the upper intestinal tract and a more efficient implantation in the colonic microbiota together with a stimulating effect of the NDO on the growth and/ or activity of both exogenous and endogenous bacteria.

Several workers in India and abroad (Christopher 1987; Karput and Pudenko 1996; Rekiel and Wiecek 1996; Spieler and Manner 1996; Tandani and Terreni 1996; Vassalo *et al.* 1997; Letellier *et al.* 2000; Naskar *et al.* 2000; Baynes *et al.* 2001; Zimmermann *et al.* 2001) have reported beneficial effects of probiotics in improving live weight, absolute gain in body weight, average daily gain and in reducing the mortality in grower pigs and promoted post-weaning gut health in piglets.

Probiotic microorganisms produce organic acids reducing pH of intestinal contents. In this way they inhibit the development of pathogenic bacteria, especially, the *Coli* group, which are the main reason for the diarrhoea in piglets. The probiotic controls the metabolic activity of the gut microflora, which leads better digestion, and absorption of nutrients. Further, use of probiotics, vaccination and acidification of drinking water has been used successfully as means of reducing *Salmonella* in pigs.

Poultry/ brolier chicken

The digestive capacity of the chicken can be modelled according to interactions between feed-related and bird-related factors known to affect energy metabolism. Gut microflora have a highly significant impact on between-bird variation in the digestive capacity of the broiler chicken. Poultry meat and eggs are important source of human pathogens. *Salmonella* is a major cause of human food-borne infections following consumption of poultry products.

Poultry are dependent up to their feed for their requirements of many vitamins belonging to "B" complex group and a few others to a major extent. When probiotics are fed to them, they can produce some of these in their bodies. Thus they promote health and longevity, as some of these essentials of health are reproduced in them. When fed as feed additives, they enhance GI function leading to improved feed efficiency and production. There is a substantial fall in losses due to infections, as their presence in the GI tract is not conducive to the multiplication of many pathogenic bacteria and coccidian. When given to sick birds or after a disease out-break in a form, they quickly regained their normal function and showed better appetite. This is more pronounced after intestinal ailments. They are useful to avert weakness at all times. Hence, feeding of probiotics is good to all types of poultry at all times.

When given as feed additives or as medicaments probiotics are safe and there is no evidence of toxicity or harm to the hosts in any way as this is nature's way of curing diseases. They pose no palatability problems, as they do not have any sort of taste or smell. They can be mixed up with feed or water easily and administration of medicaments or tonics etc.

Probiotics feeding in stress and in convalescence is helpful and useful. In ruminants, these are very much needed as they eat enormous quantities of grass and roughages. They promote digestion of these in their rumen. Some of these transient bacteria that are useful may get colonised in the GI tract after some mutation. Hence, there is a need to fed these probiotics to animals and poultry. There is an urgent need to know about probiotics fed animals in greater details.

In recent years a good number of probiotics containing different bacteria and mould cultures along-with other growth promoters are available in the market. Manufacturers are recommending different levels of supplementation in the poultry broiler ration. The manufacturers have frequently claimed that these improve growth rate, feed conversion and liveability thus resulting in economic broiler raising.
Different workers from India and abroad have reported on the use of probitotics in poultry broilers and chicken (Gandh and Nagarathanam 1990; Thapliyal 1993; Pradhan *et al.* 1998; Mandal *et al.* 2001; Giardini *et al.* 2001; Hughes and Corbett 2001; Maiorka *et al.* 2001; Immerseel *et al.* 2002) which helps in solving problems like gastrointestinal infections, low egg production, feed conversion ratio and contamination of eggs and carcasses.
The efficacy of different probiotics differ accordingly, might be due to variation in the composition of probiotics and/ or due to bacteria and growth promoters, however, the major variation has been due to bacteria. The superiority of some of the probiotics have been reported in terms of growth promotion and feed conversion resulting in better economy probably due to presence of *Lactobascillus* sporogenes bacteria. This bacterium due to spore forming has been found more resistant to the adverse conditions during the storage and in the gut also.
Role of probiotics in immune response of birds against bacterial, viral and protozoal infections has been established. Further, metabolites from intestinal fermentation can be absorbed and can significantly affect the organoleptic characteristics of poultry meat and fat. By using appropriate diets it is possible to change microbial metabolism and the ratio of the final metabolites produced. The ratios of intestinal microbial populations can also be affected by other factors such as stress and administration of substances like probiotics, prebiotics and antibiotics, which require careful controlling.

Rabbit

Probiotic has been reported to improve growth, feed utilisation and reduced mortality by maintaining microbial balance of stomach and intestine of rabbit. Very limited work has been done in India (Das *et al.* 2001a and 2001b) and abroad also (Hollister *et al.* 1990; Lacza *et al.* 1990; Nievas 1990; Blas *et al.* 1991; Abdel 1995; Gippert *et al.* 1996) on the above-said species.
It has been found that probiotics fortification of feed improved microbial balance in the gastrointestinal tract of rabbit which resulted in better digestion and absorption of nutrients which were responsible for accelerated growth, better feed utilisation and lower morbidity and mortality in rabbit. Further, post-weaning mortality had also been observed to be reduced in probiotic fed rabbits.

Conclusions & suggestions

Biotechnology is already widely used in animal production and there are numerous other potential applications, which can further be envisaged for improving the performance of animals through better nutrition. Probiotics or immune supplements can inhibit pathogenic microorganisms or make the animals more resistant to them.

Future areas of research that may help in the evaluation of prebiotics as potential ingredients for functional foods aimed at enhancing calcium bioavailability and protecting against osteoporosis.
There is tremendous scope of probiotics in alternative use of antibiotics as growth promoters for monogastric animals for the improvement of animal performance through an improved gastrointestinal health.

To recognise the potential advantages of probiotics use we need to understand how bacterial cells function in the gut ecosystem and how further it impacts the host in question?

Modulation of the bifidobacterium population in the gut, prebiotics are better candidates than probiotics, since inulin increased bifidobacterial numbers without changing the species composition, whilst the probiotics had almost no effect.

Major improvements are needed in labelling and quality assurance procedures for probiotics compounds. In addition, well-planned and controlled clinical studies are necessary to delineate fully the potential for probiotic compounds.
Sex related differences might be important in uptake and utilisation of energy and other nutrients and in response to anti-nutritional factors feed enzymes, prebiotics, probiotics, other feed additive and vaccinations against gut pathogens.

Bacterial species that have traditionally been regarded as safe are used in probitics, the mainly used strains are lactic acid bacteria and bifidobacteria that inhibit the intestinal tract.

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FEEDING OF BUFFALOES IN ARID AND SEMI ARID REGIONS

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India has 3.81 lakh Km^2 land under arid and 9.56 lakh Km^2 under semi arid conditions. Region facing annual water deficit of two third or more of the Potential Evapo-Transpiration (PET) is classified as arid and the region of this deficit ranging from one third to two third of the Potential Evapo-Transpiration (PET) is classified as semi arid region (Ramana Rao *et* al, 1983). Over 60 % of arid region of India is in western Rajasthan. In arid region soils are sandy, poor in nutrients with low water holding capacity and prone to erosion by wind and water. Natural vegetation in such climatic conditions is sparse and stunted, predominantly spiny belonging mainly to grass cover type *Dichanthium-cenchrus-lasiurus*-type and very small area having *Sehima-Dichanthium* type (Dabadghao and Shankarnarayan, 1973). The semi arid regions are defined as transition zones between arid and sub humid belts. Almost all precipitation in arid and semi arid regions occurs as rain, except in higher altitude where dew and frost is formed due to great differences between day and night temperatures. Both transpiration and evaporation are high because abundant heat energy is supplied to change the limited amounts of liquid water into water vapour either directly or through biological process thus maintaining the heat balance of the area.

Climate and nutrition of animals: The major part of the Indian sub-continent falls under tropics, where the temperatures are extreme, varying from 2^0 C to $43^{0\,C.}$ There are four well defined seasons namely summer (hot and dry), rainy season (hot and humid), autumn (mild cold and mild humid) and winter (cold and dry). The soils in India are not very fertile as compared to the temperate zones. The alluvial soils of Indo-gangetic plain and black cotton soils of Gujarat and AP are fertile, where as soils of Rajasthan, Tamil Nadu are comparatively poor. The effect of climate on the livestock is both direct and indirect.

Direct effects of extreme of climate on livestock: The direct effect of climate is both on the vegetative growth, which provides feed supply, and on the animal, which affects production. In India the climatic effect on the vegetation is more marked as availability of fodder for livestock is affected.

Indirect effect of extreme of climate on livestock: The major indirect effect of climate is on the quantity and quality of feed available for ruminants. The most important climatic factors which affect the plant growth and hence the quantity of feed available are temperature, length of daylight, intensity of solar radiation and rainfall.

Arid and semi arid lands experience stress due to climatic variability and increasing requirement of livestock and human population. Over exploitation of natural resources by increasing biotic pressure is throughout the country but in arid and semi arid areas the situation is more desperate. The population pressure gets further compounded by droughts causing extreme pressure on vegetation through over stocking. The existing grazing pressure in arid area is very high i.e. 1 to 4 ACU/ha against the normal 0.2 to 0.5 ACU/ha (Beniwal and Singh, 2005). It has resulted in alarming scarcity of feed and fodder, which poses great problems in meeting nutritional needs of livestock.

An area of about one million hectare in semi arid India is subjected for grazing 7.4 million cattle, 5.6 million sheep, 3.38 million goats and 6.6million other animals. Over grazing has not only reduced the production of biomass over the years but also deserted considerable area. Use of improved management practices, protection of native pasture and introduction of improved varieties of legumes and grasses suited to respective agro-climatic zones may cope up the effect of over grazing upto certain extent. (Singh *et al.*, 2005).

In the arid and semi arid regions of India where rainfall is low and erratic, the availability of grazing is seasonal. During rain good pastures are available whereas during the dry season dry and poor quality herbage is available. The drinking water for the animals also becomes a big problem in the arid and sub-arid regions. Table1 shows the common feeds and fodders of arid zone and their composition.

Forage resources in arid and semi arid region: Forage includes browse and herbage which can be consumed as such by the animals or harvested and fed to the animals.

1. **Cultivated fodder production:** On account of gradual reduction in range and forest land and availability of poor quality and inadequate bio-mass from grazing land, cultivation of fodder crop and production of crop residues has become an integral part of the sustainable livestock productivity in the country. Table 2 shows the cultivated fodder species suitable for different regions. There is ample scope for production of fodder crops under dry land region of the northern plains without affecting the rabi crops. (Singh *et al.*, 2005).

2. **Grazing land:** Grazing lands in India are considered to be an important source of biomass for sustainable livestock production for the poor and landless farmers. Grazing based livestock production is a predominant occupation and the major source of livelihood for landless and marginal farmers in the country. The area under pasture land is generally unprotected and inhabited by native biomass. The waste lands and lands which are not being used for arable cropping are used for grazing (Beniwal and Singh, 2005).

3. **Supplementary feeding in scarcity:** Scarcity of feed and fodder resources in arid and semi arid regions and occurrence of frequent famine necessitates huge amount to be spent on transportation of feed from surplus areas. Due to the poor nutritional quality as well as deficient quantity of feeds and fodders in arid and semiarid regions, feeding of supplements (of energy, protein, and minerals) is recommended. In Indian as well as in most of the developing countries, fibrous crop residues are the major feed for buffaloes. These fibrous crop residues are poor source of nitrogen, energy and minerals and can not meet the needs of rumen microbes. Urea molasses mineral block (UMMB) is a very useful to supplement the deficient nutrients like fermentable nitrogen, easily available energy and all the macro and micro essential minerals.

4. **Role of buffalo in indian economy:** Buffalo produces 56.0 % of total milk production and 30.0 % of total meat produced in the country. In 2004-05 buffalo meat export was of value equal to Rs.1700 Crores and contributions of buffalo milk in Indian economy is Rs 60228.64 crores (Ranjan, 2006). Buffaloes in India are primarily reared for milk production along with limited use of males for draught and meat production. Buffalo contributes significantly to human nutrition.

Animal husbandry in rajasthan

Table 3 shows the numbers and position of India in world livestock. Table 4 shows the livestock population of the Rajasthan state during the censuses of 1992, 1997 and 2003. This table shows that from 1992 to 2003, there was significant increase in buffalo, swine and poultry populations in the state i.e. stall fed livestock population increased. Camel population is declining at a fast rate during the last three livestock censuses. During 1997-2003 cattle population also decreased. From the data in this table it is evident that farmers are interested in rearing those species of livestock, which are not taken for long distances in search of feed resources and are adopting stall fed livestock rearing. This may be due to several reasons i.e. value addition in agricultural produce to earn livelihood, better transport facilities for transportation of feed, availability of water etc. After the agricultural farming, livestock is the most important source of livelihood in Rajasthan. In western region of the state, which is arid, and the potential for agricultural farming is limited, livestock has provided livelihood security to the farmers and nomadic groups (Chaudhary et al, 1999). Animal husbandry contributes over 15 per cent to the net state domestic product. Rajasthan has the largest livestock population in

India; contributing nearly 40% of the wool and 10% milk production in the country (Rajiv *et a.l*, 2000; Ministry of Agriculture GOI; Govt of Rajasthan).

Buffalo in arid region

In Rajasthan there are 10414 thousands buffaloes contributing about 60.83% of the total milk production in the state (Tables 5 and 6). The tables also show that except Maharashtra, in all the major milk producing states of the country, more than 50% milk is produced by buffaloes. In arid region, livestock farming makes agricultural farming more sustainable and economically viable. Probably due to this reason the arid region of the country is better ranked than rest of the regions in terms of production of milk (>18%), meat (>20%) and live animals and fibre (> 25%) (Gahlot, 2005). Milk productivity of buffaloes in Rajasthan is lower than in the other major milk producing states in the country because of poor genetic germplasm and nutritional deficiencies. However, farmers of Rajasthan with adjoining Haryana have very good numbers of Murrah buffaloes yielding more than 10 kg. of milk.

Microbial activity in rumen: Reticulo-rumen represents a complex ecosystem and efficient fermentation vessel in cattle and buffalo, which is inhabited by bacteria, ciliate, protozoa and anaerobic fungi. These organisms are primarily involved in degradation of carbohydrates, nitrogenous substances and lipid components of the feed and produce fermentation end products, such as, volatile fatty acids (VFA), carbon dioxide, methane and ammonia. The energy generated in the process is used in the biosynthesis of cellular constituents, which then are digested in the lower gut to serve as nutrients for the host. The anaerobic fermentation converts the substrate energy into VFA, which are absorbed and utilized as energy source by the host.

Buffaloes utilize cellulosic fibrous feeds more efficiently than cattle. The superiority has been attributed that this species possesses more and efficient micro flora in the rumen. The distribution of cellulolytic bacteria has been shown to be wider in buffaloes than cattle; however, cellulolytic bacteria differ in their ability to hydrolyse cellulose from different sources of feed in buffalo rumen. Proteolytic and amylolytic bacterial count was recorded 5-7 folds higher in buffalo than in cattle. Feed composition, post-feeding intervals, feeding frequency, soluble sugars, lipids and rumen pH influence rumen protozoal population. The predominant microbial species present in the rumen of cattle and buffalo have been listed in Table 7. Protozoa contribute directly or indirectly to fibre digestion in rumen. Protozoal counts, especially Entodinium, tended to increase in buffalo rumen with an increase in dietary concentrate. Negative effects of lipids on fibre degrading organisms in particular have been reported. The fungal attack weakens the tensil strength of fibre fragment, therefore, more sites are available for bacterial action in the rumen. All the anaerobic rumen fungi have been shown to be cellulolytic in nature besides having proteolytic activity. Bacterial counts recorded in buffaloes caused marked increase in the level of ruminal ammonia (Sharma, 2006).

Feed utilization on different planes of nutrition: Buffalo exhibited higher number of rumen amyolytic bacteria as well as cellulolytic bacteria on wheat straw and concentrate diets compared to cattle. Buffaloes have been reported of having higher capacity to digest dietary crude protein and crude fibre than cattle. Higher crude fibre digestion in buffaloes may be due to narrow calorie-protein ratio, which is better suited to proliferation of ruminal cellulolytic microbes. The additional causes for a better conversion of feed in buffaloes may be attributed to longer retention of feed in the digestive tract, favorable rumen conditions for ammonia nitrogen utilization, higher capacity to handle stressful environment and a wide range of grazing preferences. Nutrients digestibility with NPN supplements were also observed better in buffaloes compared to cattle (Sharma, 2006).

Precursors to synthesize milk: Nutritional requirements for the general metabolism and for synthesis of milk constituents are derived from feed consumed by the animals and extracted through blood. The substrates attracted from blood by the lactating mammary gland are glucose, amino acids, fatty acids, mineral and vitamin constituents (Table 8). Acetate and βydroxy butyric acid are prime substrates for ruminants. The energy source for synthetic process is oxidation of glucose and acetate in citric acid cycle.

Nutrient Requirements and computation of ration for buffalo: The requirements for milk production may be computed in accordance with the information given in Tables 9 and 10. The nutrient requirements for milk are added to the maintenance requirements to arrive at the total requirements of lactating buffaloes. Example in Table 11 illustrates the computation of ration for a buffalo weighing 450 kg and producing 8 litres of milk per day with a fat content of 6.5 per cent. The maintenance requirements of the buffalo are 248 g DCP and 3.4 kg TDN (Table 9). The requirements for milk production are 636 DCP and 3.64 kg TDN (Table 10). Thus the total requirements are 884 g DCP and 7.04 kg TDN. The feeds available are concentrate mixture (10% DCP, 75% TDN), green berseem and wheat straw. Illustration in Table 11 shows that the nutritional requirements can be met from these feeds as indicated. Similarly, example in Table 12 illustrates the computation of ration for a buffalo weighing 650 kg and producing 12 litres of milk per day with a fat content of 7 per cent. The maintenance requirements of the buffalo are 327 g DCP and 4.4 kg TDN (Table 9). The requirements of milk production are 996 g DCP and 5.76 TDN (Table 10). Thus the total requirements are 1323 g DCP and 10.16 kg TDN. The feeds available are concentrate mixture (16% DCP, 72% TDN), green maize fodder and barley straw. Illustration in Table 12 shows that these requirements can be met from these feeds as indicated (Punia *et al.*,1999).

In feeding systems where buffaloes are well fed to appetite on roughages/pastures following calving, the bulky nature of the feed may limit the actual intake of nutrients. The animals may then use body reserve to meet the production stimulus. For this reason high producing buffaloes may lose weight following calving. Although meals or concentrates are expensive in comparison to forages but it is desirable to feed at least 2-3 kg concentrate per head per day to buffaloes during early lactation to minimize this weight loss. The objective for the first two to three months is to fully feed the buffaloes to appetite so that they are able to produce to a maximum with high peak yield. Adequate feeding over this period will also minimize the weight loss, enable this loss to be regained rapidly and ensure that buffaloes are in a sound condition at mating. Considerable research has been carried out to study the effects of different types of supplements over the critical early part of the lactation especially in cattle. The most important feature is that continued heavy feeding of a supplement that has a lower feed value than the quality pasture/fodder will reduce lactation production because a degree of underfeeding is being imposed. Heavy feeding of hay or silage to buffaloes particularly high yielders during early lactation means that overall level of nutrient has been lowered and underfeeding results. So under these circumstances rather than depressed production for whole lactation, concentrates should be fed to overcome the degree of underfeeding. A useful guide is to supplement with approximately 0.5 kg of concentrate for each kg of hay or silage on dry matter basis. In another way buffaloes with high milk production potential should be fed adequate concentrate to prepare them to produce at the maximum levels in subsequent lactation.

Table 1. Common feeds and fodders of arid zone and their composition (on % DM Basis)

Feed and Fodder	DM	CP	CF	Total Carbohydrate
Legume straw				
Moth Chara (Phaseolus aconitifolius)	87.4	9.7	25.2	73.6
Gram Straw (Cicer arietinum)	91.3	4.8	44.6	85.6
Groundnut Straw (Arachis hypogea)	89.1	8.1	40.63	80.5
Guar Phalgati (Cyamopsis tetragonoloba)	87.3	8.9	24.1	75.7
Average	**88.8**	7.9	33.6	**78.8**
Cereal Straw				
Sewan grass (Lasiurus sindicus)	88.0	3.1	36.8	84.4
Bakaria (Indigofera cordifolia)	82.2	6.2	28.2	73.1
Anjan/Dhaman (Cenchrus ciliaris)	83.9	8.2	30.54	73.8
Lampa (Aristida depressa)	86.9	2.1	36.8	84.4
Gokhru (Tribulus terrestris)	83.7	19.11	16.75	62.1
Dub (Cynodon dactylon)	88.2	10.47	28.17	75.4
Gramna/Blue panic (Panicum antidotale)	91.4	7.26	40.47	83.6

Makra (Dactyloctenium aegyptiacum)	87.7	8.32	35.19	75.7
Bui (Aerva tomentosa)	87.9	5.0	32.1	82.4
Karad (Dichanthium annulatum)	85.3	7.39	28.17	75.8
Grass mixture	88.5	4.39	32.43	84.0
Average	86.7	7.4	31.9	77.7
Shrubs and Trees				
Babool (Acacia arabica)	93.2	7.04	33.32	84.5
Phog (Calligonum polygonoides)	87.1	6.5	30.2	79.1
Siras/Sares (Albizzia lebbek)	85.4	16.81	31.52	67.7
Peepal (Ficus religiosa)	84.3	9.02	15.93	68.3
Khejri (Prosopis cineraria)	84.1	14.7	15.14	68.1
Jhar beri (Zizyphus numularia)	92.4	11.53	33.82	80.6
Kikar (Acacia nilotica)	87.7	15.98	7.50	69.7
Kher (Acacia catechu)	87.2	13.03	22.55	73.5
Average	**87.46**	**12.03**	**23.82**	**72.74**

Source: Singh and Saini, 2002

Table 2. Cultivated fodder species suitable for different regions in India

S.N.	Regions	Rainfed	Irrigated
1	Arid	Jowar, bajr, moth, guar, lobia,	Lucerene, berseam, oats, maize, bajra,
2	Semi Arid	Jowar, bajr, moth, guar, lobia, velvet bean, field bean, moong	Jowar,maize, lobia, teosinte, lucerene,berseem,sarson,turnips,hybrid napier, oats, sudan grass, guinea grass,setaria,Rhodes.
3	Sub-humid	Dinanath grass, jowar,lobia, rice bean, velvet bean, teosinte, sunnhemp	Berseem, oats, sudan grass, hybridnapier, guar, jowar, maize,para, Rhodes, setaria.
4	Humid	Jowar, Dinanath grass, rice bean	Berseem, oats, hybrid napier,guinea, lucerene, sarson, turnips,setaria,para jowar
5	Lower hills	Jowar,lobia,velvet bean, field bean, guar	Maize,jowar,oat, berseem, Lucerne, hybrid napier, sudan grass, setaria, Rhodes.

Singh et al (2005)

Table 3. Livestock population (millions) of important livestock species in India and World (2003).

Species	India	World (FAO estimates)	India's Share %	Rank	Next To
Cattle	185	1366	13.54	First	
Buffaloes	97	167	58.08	First	
Camels	0.6	18.5	3.24	Fifth	Somalia, Sudan, Ethiopia, Pakistan,
Sheep	61	1034	5.9	Third	Australia, China
Goats	124	743	16.7	Second	China
Poultry	489	15854	3.08	Sixth	China, USA, Brazil, Mexico, Indonesia

Source: Agricultural Research Data Book 2004. Agricultural Statistics at a glance, 2003, Directorate of Economics and Statistics, Ministry of Agriculture, Govt of India.

Table 4. Livestock population (thousands) of Rajasthan and percent changes during the last three censuses.

Species/Types	1992	1997	% Change	2003	% Change
Cattle	11595	12158	4.9	10854	-10.73
Buffalo	7746	9756	25.9	10414	6.75
Sheep	12168	14312	17.6	16054	12.17
Goat	15062	16936	12.4	16809	-0.75
Horses and ponies	24.63	23.31	-5.3	25.00	7.25
Donkeys	192	186	-3.1	143	-23.4
Camels	730	668	-8.6	498	-25.45
Swine	248	303	22.2	338	11.55
Poultry	3000	4380	46.0	6192	41.36

Source: Statistical Abstract of Rajasthan (2004), Directorate of Economics and Statistics, Govt. of Rajasthan, Jaipur.

Table 5. Share of milk production by cows, buffaloes and goats (000 tonnes) during 2003-04

States	Cow	Buffaloes	Goat	Total
Gujarat	2062	4116	243	6421
Haryana	1023	4089	109	5521
Madhya Pradesh	2163	2887	338	5388
Maharashtra	3163	2915	301	6379
Punjab	2206	6140	45	8391
Rajasthan	2291	4899	864	8054
U.P	4440	10512	991	15943
A.P.	1750	5209	-	6959
Bihar	1011	1824	345	3180
India	34973	47979	3708	88082

Source: Agricultural Research Data Book 2004. Agricultural Statistics at a glance, 2003, Directorate of Economics and Statistics, Ministry of Agriculture, Govt of India.

Table 6 Share of Milk Production (%) by Cows, Buffaloes and Goats in major milk producing states of India during 2003-04.

States	Cow	Buffaloes	Goat	Total
Gujarat	32.12	64.10	3.78	100
Haryana	19.60	78.31	2.09	100
Madhya Pradesh	40.15	53.58	6.27	100
Maharushtra	49.59	45.70	4.72	100
Punjab	26.29	73.17	0.54	100
Rajasthan	28.45	60.93	10.73	100
U.P.	27.85	65.94	6.22	100
A.P	25.15	74.85	-	100
Bihar	31.79	57.36	10.85	100
India.	39.71	54.47	5.82	100

Source: Agricultural Research Data Book 2004. Agricultural Statistics at a glance, 2003, Directorate of Economics and Statistics, Ministry of Agriculture, Govt of India.

Table7. Predominant microbial species reported in rumen of cattle and buffaloes

Microbial species	Cattle	Buffaloes
Cellulolytic	Ruminicoccus flavefasciens Ruminicoccus albus	Ruminicoccus flavefasciens Fibrobacter succinogenes
Proteolytic	Streptococcus bovis Prevotella ruminicola	Streptococcus bovis Ruminibactor amylophilus
Protozoal	Entodinium simplex Diploplastron Epidinium	Entodinium candatum, Diplodinium Ostracodinium

Table 8. Blood precursors of the milk constituents in ruminants

S.N.	Milk Constituents	Blood Precursors
1	Water	Water
2	Lactose	Glucose
3	Casein	AA
4	βLactglobulin	AA
5	αLactalbumin	AA
6	Immune globulins	Immune globulin
7	Fatty Acids	Acetate, βhydroxybutyrate, blood lipids
8	Glycerol	Glucose, glycerol from tryglycerides
9	Mineral	Minerals
10	Vitamins	Vitamins

Table 9. Daily Nutrient Requirements of Adult Non-Producing Buffaloes (Kearl, 1982)

Body Wt. (kg)	Gain (kg)	Dry Matter (kg/day)	DCP (g)	TDN (kg)	Ca (g)	P (g)	Vitamin A (1000 IU
Producing 4 kg milk containing 7% fat							
350	0	6.3	205	2.8	14	11	15
400	0	7.0	227	3.1	17	13	17
450	0	7.6	248	3.4	18	14	19
500	0	8.2	268	3.6	20	15	21
550	0	8.9	288	3.9	21	16	23
600	0	9.5	305	4.2	22	17	26
650	0	10.3	327	4.4	23	18	28
700	0	10.6	346	4.7	25	19	30
750	0	11.0	364	4.9	26	20	32
800	0	11.5	382	5.2	27	21	34

Table 10. Nutrients Required for Production per kg of Milk to be added to the Maintenance Requirements (Kearl, 1982)

Fat content (%)	DCP (g)	TDN (kg)	Ca (g)	P (g)
4.0	61	0.34	2.7	2.0
5.0	69	0.38	2.9	2.2
6.0	76	0.43	3.1	2.4
7.0	83	0.48	3.3	2.6
8.0	90	0.53	3.5	2.8
9.0	97	0.57	3.7	3.0
10.0	104	0.62	3.9	3.2
11.0	111	0.67	4.1	3.4

Table 11. Computation of ration for a buffalo (450kg body weight) yielding 8 litres of Milk per day with a fat content of 6.5 percent.

Feed	Fresh weight (Kg)	DM (kg)	DCP (g)	TDN (kg)
Concentrate mixture	2.0	1.80	180	1.35
Berseem	30.0	5.40	751	3.60
Wheat Straw	5.5	4.95	000	1.98

Table 12 Computation of ration for a buffalo (650 kg body weight) yielding 12 litres of milk per day with a fat content of 7 per cent.

Feed	Fresh weight (Kg)	DM (kg)	DCP (g)	TDN (kg)
Concentrate mixture	6.0	5.40	960	3.90
Maize green	30.0	7.50	360	5.40
Barley straw	2.5	2.25	18	1.06

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MANAGEMENT AND FEEDING OF SHEEP DURING LIMITED FEED RESOURCES

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Introduction

In many ways cultural life in India is closely associated with livestock. The contribution of livestock to the national economy is indeed vast. The livestock production systems generally followed in the country based upon mixed farming in which crop-livestock integration is the tradition. Cattle and buffalo are raised in small mixed farms. Sheep and goat raising through small and marginal farmers and agricultural labourers offers good scope in the country. Sheep and goat contribute about half of the total meat production of the country. As per 2003 census the sheep population with 61.47 million sheep India ranks 4th in the world (4.5% of world sheep population). Sheep producing about 50.94 million kg (2002-03) wool with average of 800 grams/sheep and contributes about 170 million kg of mutton and 40 million kg of skin.

Nutrition plays a major role in the overall productivity, health, and well-being of the sheep flock. Because feed costs account for approximately two-thirds of the total cost of production, it is important that producers consider nutrition management a top priority. Nutrient requirements of sheep vary with differences in age, body weight, and stage of production. During the grazing season, sheep are able to meet their nutrient requirements from pasture and a salt and mineral supplement.

Forages constitute 75 to 90 percent of the total diet for sheep. Sheep are excellent converters of forage to meat and fiber and consume a wide variety of forages, and selectively graze numerous weeds and other pasture menaces. Companion grazing of sheep with other species of livestock, such as cattle or goats, results in greater pasture utilization and higher quality pastures than when a single species is grazed alone.

Pasture

Permanent pasture should be the predominant source of nutrition for the sheep flock. Intensive sheep production systems where the sheep are housed and fed harvested feeds are not as profitable as more extensive production systems where they harvest their own feed. When a sufficient quantity of forage is available, sheep are able to meet their nutrient requirements from forage alone along with a supplemental source of salt and minerals.

Draught action plan

Since droughts are part of life for sheep farmers in the country, Planning and decision making must be done as soon as you recognize the possibility that the poor season may progress to a drought. If you leave the decisions until the drought worsens, many of the management options available early may be closed to you. Prices for sale stock usually drop dramatically, pastures dries up, fodder prices generally soar and off farm employment becomes difficult to find.

However, each drought brings its own set of difficulties. How well you survive the drought will depend on the initial plan of action and the modifications undertaken to the strategy as the drought progresses. The first step is to list the farm's financial and physical resources so that the effects of various strategies, both short and long term, can be calculated. Water is probably the first thing to consider as if this resource is inadequate, then it will be difficult to retain large numbers of stock. The next step in choosing a drought action plan is to estimate when you think the drought will break. This will affect your calculations on how long you will be feeding sheep, how much it will cost and whether you will decide to sell stock or not. It is best to over estimate the time you expect to hand feed your sheep to be on the safe side.

Migration

Sending sheep away on migration is sometimes more economical than feeding and the time saved from feeding might be more usefully employed. It also releases more feed for the stock remaining on the property. Don't forget to inquire in your own district, especially early in the drought, as you may be able to find ungrazed paddocks for rent. However, if the drought becomes more widespread, it is harder to find place nearby for grazing the animals and the cost rises rapidly. It may then be cheaper to feed stock at home. It may also be costly and impractical to supervise sheep (especially lambing ewes) at a distance

Selling

Selling sheep is one option where early planning and action is advantageous. In particular, selling decisions should be made before stock have lost too much condition to be saleable and market prices have started to drop.

Feeding

The Class and stage of production of the animals dictate the type and quality of forage to be grazed. Lactating ewes with lambs are placed on the highest quality pasture available to promote desired levels of milk production and lamb growth. Dry, non-pregnant ewes or ewes in early to mid-gestation are placed on lower quality forages or serve as second grazers behind young, growing lambs. Strategies that match stage of animal production with type and quality of forage improves overall forage utilization while maintaining optimum animal performance.

The aim of feeding sheep in a drought is to maintain weight in dry sheep and to meet the requirements of late pregnant and milking ewes. You should allow for enough growth of lambs and weaners so that they do not suffer permanent checks. Feeding should be started well before the sheep become weak. It may take some time before they become accustomed to hand feeding and begin eating their ration. If sheep have lost too much condition before feeding has begun, or before they readily accept grain, it may be hard to lift their live weight back to desirable levels. This is particularly applicable to lambs or weaners that were not fed supplements when grazing with their mothers.

Adult sheep, which are above these starting weights, can be allowed to lose some weight and condition at the start of a drought. This weight loss should be controlled. A drop in weight of 5 kg over a number of weeks and a drop back to store condition will save a lot of feed.

Using the rule of thumb based on condition scores, stop feeding gradually when less than a quarter of the stock remains at a fat score of 2 or less, after the drought breaks. In previous droughts, many breeders have experienced their heaviest losses during the period immediately following drought-breaking rain. Prolonged wet conditions turn sheep off their feed. In most circumstances, sheep are kept confined to restricted feeding areas until adequate pasture is available. At that point, allow increasing grazing time each day until full grazing is provided after 6 to 7 days. Allowing immediate full grazing will lead to digestive disorders.

Other Management Decisions

Shearing, pregnancy and lactation all increase the nutritional requirements of the sheep flock. Changes to mating, weaning and shearing times can sometimes be used to reduce feed demands during the drought.

The cost of drought feeding a breeding ewe for six months (including late pregnancy and lactation) is about 50% more than for a dry ewe, so savings can be made by delaying joining or by not joining. However, the long term effect of this action needs to be carefully considered

Delaying the time of joining for an early autumn lambing flock has the potential to greatly reduce supplementary feeding costs. Joining may be put back a few weeks or changed to a late winter/spring lambing.

Although a change in the time of joining or reducing the number of ewes joined may save money or supplementary feed in the short term, this benefit must be weighted up against long term costs. Factors such as complicating management, disrupting the flock structure and altering future income levels need to be considered.

Early weaning, if not already practised, can reduce feed costs and simplify management of both the ewes and the lambs. The ewes can then be managed as dry stock and the lambs given priority.

Crop Residues

Crop residues are a major source of roughage to Indian cattle. Fibrous crop residues like rice and other cereal straws are the major feed resources of the country. Even though the livestock feedstuffs are in short supply, still most of these crop residues are not effectively utilized. Usually in many parts of the country these materials, especially rice straw and other cereal straws, are wasted as they are fed in long form without chaffing. Further, the methods developed for improved utilization of these low-quality crop residues are not commonly practiced by the farmers as the advantage of these methods have not been demonstrated at the farm level. Hence, the nutrients from these crop residues are also wasted to a great extent. In order to utilize effectively the available crop residues, the methods for improved utilization of low-quality roughages like chaffing, ammonization with urea, ensiling, supplementing with leguminous fodder, enrichment with deficient nutrients, etc., should be demonstrated in each village so that the farmers can be convinced of the advantages.

Agro-industrial By-products

The by-products obtained from grain processing (brans), oil seed processing (oil meals), pulses processing (chunni) are the major and important feed ingredients that are commonly fed to Indian livestock as concentrate feeds. Almost all the quantities of these by-products produced in the country are utilized as livestock feed. These by-products are considered as traditional or conventional feedstuffs. The brans are the main source of concentrate feeds accounting to more than 40 percent of the total concentrate feeds produced in the country. Another important source of concentrate feeds are oil meals constituting more than 20 percent of the total concentrate feeds produced. Thus, these two industrial by-products cover more than 60 percent of the total concentrate feeds fed to Indian livestock.

Conservation of feed stuff

Considering the difficult situation in feedstuffs availability in the country there is an urgent need for the conservation of feedstuffs for obtaining optimum output by feeding balanced rations to the superior stocks, cross-bred and indigenous breeds and their followers. The low-producing, uneconomic stock and the unproductive animals can be maintained on subsistence allowance till they are eliminated. Popularization of feeding balanced diets will reduce wastage of nutrients and ensure economy. Reduction and elimination of worm burden and shortening of dry periods is an effective way of feed utilization.

ADVANCES IN BALANCED FEEDING OF CAMEL FOR ITS OPTIMUM DRAUGHT POTENTIAL

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The history of development of camel is narration of a series of evolution, migration and extinction of interest as well as concern. Which communicate occurrence of early evolution of camelidae to be entirely in North America along with surprising spread in he late teriary age to the South America and via Asia to Africa, becoming extinct in North America and recognize dry land ecosystem as habitat.

The dromedary was probably domesticated on the south cost of the Arabian Peninsula in the region of present day Yemen and Oman around 3000 to 4000 years ago and then introduced with the spice trade in to North Africa and the horn of Africa. Today there are about 15 to 16 million dromedaries in Africa, Middle East and the Indian sub-continent.

The camel production is besieged with rampant insulting nature of adverse climatic conditions and onslaughts of scarcity of feeds and water frequented by recurring low rain fall, failure of crops, meager vegetation resulting in famines, subjecting livestock to nutritional crises. But this unhomed pseudo ruminant seemed to have accommodated so well to the arid and semi-arid regions and in the socio-economic pattern of the pastoral industry that Inspite of these all aforesaid adversities the versatility and adaptability of the camels to the arid and semi-arid zones due to their anatomical as well as behavioral peculiarities, physiological adjustment and foraging ability such as browsing habits rendered them non-vulnerable to competition to scarce vegetation reinforced with remarkable refractoriness to water deprivation in dry hot arid region.

The outstanding tolerance to the rugged climate of high temperature, water deprivation, endurance for hunger and scarcity has made this animal to be of great use. Besides the cushioned feet and muscular fore-limbs supporting pull, the lashing hind-limbs bring about a four wheel drive action in sandy soil. These features in combination with peculiar behavioral superiority as keen sense of night navigation rendered this animal since ancient time as most prefel-ential or even some times only riding and pack animal in desert.

As far as utility of this ungulate in arid desertic tract is concerned, it is refer 1-ed as excellent means of currying load, transportation agriculture and defense services in conditions where other animals are scared and failure. Beside these, its hide, wool, milk and even meat available as byproduct, additionally contribute for better economy of the rural areas.

However, it is because of their survivability, elasticity, diversity and rewal-ding remunel-ative economic value, the density of the camel population is escalating in the desertic countries like, India with just 0.7 million camels in 1966 showed spectacular rising trend and touched 1.45 million in 1990 (FAO 1990) which is third highest in the world. Most of Indian camel population (about 82.20%) is rest 1-icted in the arid and semi-arid areas of three states (Rajasthan, Haryana and Gujarat) with maximum concentrates i.e. 59.30% of total in Rajasthan alone.

If given a chance camels prefer browsing to grazing as large size of the neck, conformation of the lips and teeth help camel to brows and are therefore well adopted as the third story feeders by nibbling tree leaves at height of 12 to 15 feet even on the twigs of the trees which are often spiny. Though camel do not relish grasses but still feed on a wide variety of vegetation growing in nature and do Dot seem to disfavor any vegetation within reach that are found through out their expense of the desert belt of Asia and Africa and eat with impunity certain toxic plants such as Subabul (Leucaena leucocephala), iron wood (Erythropheum chlorostachys) and buck bush (Gyros.emon Australia,sjcus) etc. responsible for heavy losses in other species (Purohit 1995).

Initially the camel nutrition research was taken up at Western Regional Animal Nutrition Research Station, Anand, under ICAR project on "Feed and Fodder Survey of Western Region" and at College of Veterinary and Animal Science, Bikaner under ICAR project entitled "Investigation on Camel Nutrition in Rajasthan Desert" and other studies (Mathur and Purohit 1979a, Gaur 1979b Gaur 1982 et al). Under these projects survey, proximate analysis and digestibility/metabolism studies conducted for common camel feeds showed that due to shrinking vegetation browsing is not sufficient for obtaining enough nutrients to fulfill the requirements and the natural flora (tree leaves, shrubs, bushes etc.), products of the desert prone agriculture crops apparently not useful for human consumption or industries and the byproducts of leguminous crops such as moth straw, gaur phalgati, gram straw etc. form the principle feed and fodder resources for camel (Table-1). Recently with the inception of Indira Gandhi Canal the residue of groundnut crop i.e. groundnut fodder, which is very nutritious, have also become an addition in the resources. For working camels supplementation with concentrate such as, Moth, Gaur Gur, Methi and Alum is generally done to meet the nutritional needs as well as to upkeep their body studies on substitution by urea as NPN source and protein protection with or without supplementation of urea indicated that protein protection and supplementation of protected protein with urea could be followed safely and effectively. (Mathur and Purohit 1979, Sharma and Purohit, 1992).

It is evident from many nutritional studies that camels are very efficient in utilizing high fibrous diet and the digestibility of under fiber is comparatively higher in camels than other ruminants. In the arid zone of Rajasthan the camel brows many available desertic vegetables (non conventional) such as ker (capparies decideca) neem (Azardirachta indica) kikar Acacia arefica poges of village kiker (Prosopsis juliflora) isradis babool (Acacia tovlatis) jal (selvidera oteoides) Tumba (citvalus colycyrifries) kheenp (Laptadenia tyrotechnica) bui flerva Persia) lana (salsola baryosma) phog (calligonum polygonoidis) Dhaman (Cenchrus ciliaris Bhurat (canchures biflorus, blue panic (Paniceas antidotal) Bakaria (Indigofera cordifolia) sokuru (Tribulius terriestalis) ber (Andropogan lasiger) plant (Paricum turgidems). These fodder vegitation are invariably consumed by the camels during long famine or scarcity period.

The results of some studies showed that there is no effect of high tanic acid complete of feed on digestibility of humidity particularly crude protein in camel these animals can vary efficiently utilize the feed plants and than there is no effects on toxic in rudient sun in minosit subabool (Lacucim loateru) on long term feeding.

The studies taken up so far illustrate an apparent wide variation in nutrient intake by a relatively uniform population of camels undertaking similar exercise regimes.

The generalized recommendation for nutrient allowances with regards to DCP in pal-ticular suitable for raising of young camels with respect to the approximate body weight and to ghe age could be used in the ration as a thumb rule for practical feeding and formulation of rations. (Purohit 1995).

Body weight	Age	DCP requirement
350 kg approx.	3.3 Year	0.34 kg
400 kg approx.	3.9 Year	0.47 kg
450 kg approx.	4.6 Year	0.59 kg

Similarly, requirements of metabolizable energy for maintenance (MEn) in adult and pregnant camel have been reported (Jackmola 1993). These were considered to be lower than that of cattle and suggested to reduce further during dehydration. The requirement of energy for maintenance and during last quarter of pregnancy is as under :

Body weight (kg)	Adult camel (Meal/day)	Pregnant camel (Mcal/day)
300	7.21	9.6
400	8.94	11.9
500	10.57	14.1
600	12.12	16.1
700	13.61	18.1
800	15.05	22.6

Additionally, it was observed that dry matter intake and body weight gains were lower in a group of camels receiving no concentrate than the group receive high and medium quality concentrate indicated that supplementation could be used as a tool for exploiting potential of camel (Jakhmola. Similarly it was also observed that supplementation of 40% barley as source of energy was superior and most effective to enhance body weight gain (Sandoo 1994). Regarding nutrient utilization in pack (camels the experiments were taken up at NRCC on Bikaneri camels with and without after stress and it was observed that camels fed ad lib dry fodder of moth chara (phaseolus aconitifolius) with no water stress after completing safari of 950 km in Thar desert during winter and daily sent to 10 km journey with pack load of 100 kg 2 riders (114 kg) indicated no deficiency problem Rai et al 1995, camels maintained their body weight and could cope with work stress. Similarly camels subjected to water stress by offering water twice weekly, fed same fodder @ 1.33% DMI proving 0.34 kg DCP and 68.0 mj ME also did not exhibit any ill effect and camels could go well with this much work and water stress. These suggest that pack animals could be maintained well on leguminous fodders without essentially supplementing concentrate.

Regarding utilization of nutrients and nutrient requirements in racing camels very meager efforts have been made in the country. However, recently the preliminary studies made in country at National Research Centre on Camel, Bikaner showed increase in DM and water intake during racing period then at rest due to higher nutrient demands of muscular work in racing camel (Nagpal et al 2000).

A survey was conducted in four large training campus in the U.A.E. for calculating intake of energy and protein. On comparing these intakes with published recommendations for 450 kg camels performing similar exercise regimes, the majority of rations having Barley, Green alfa alfa, milk, dates, grass, pellets and mixed grain provide adequate energy and excess protein to meet the needs for maintenance and daily 20 km sub maximal training exercise. (Kohnke & Cluer 1992).

Recommended as daily maintenance requirement were 270 g of DCP and 49 MJ of ME for a 450 kg camel based on data published for other ruminants (Wilson 1984). Whereas, studies conducted by Guerouali and Zinc (1994) suggested a MEm of 0.31 MJ MEm/kgw 0.75 compared to 0.50 MJ Mem/Kgw 0.75 suggested earlier by width on 1984. However, it was a so concluded that camels have a daily maintenance requirement of 145 gm DCP/body wt. 0.75 or 1429 DCP for a 450 kg camel at rest (Gihard & Bovedy 1992).

One of the very important oxygen uptake study on 500 kg racing camel exercised at racing peed of 35 km/h on a treadmill, demonstrated a gross energy ue at 100% Vo2 of 0.63 MJ?Min. (Evan et al 1992).

So far no information regarding fat requirements for camels is available. However the substitution of rumen undegradable fat sources for conventional carbohydrate has been evaluated in racing camels using iso energic diets. In this study, it was found that upto 200 gm of protected fat could be substituted for cereal energy sources without metabolic disturbances. (Wensvoort 1992).

Studies on nutrient intakes of draft camels during rest and load pulling were conducted at NRCC on adult male camels given dry moth chara as sale diet. The camels were given pay-load of 2.5 kg/kg body weight by subjecting to two and four wheel carts for 6 hrs continuously. The findings of experiment suggested increase in DMI, digestibility of nutrients and nitrogen retention due to the higher nutrient demand for work. The loss of body weight appeared in load pulling animals indicated the need of nutrient supplementation to maintain the charnels body weight and work output.

Studies on mineral nutrition of camels reported negative calcium and phosphors balance on feeding some feeds and suggested their supplementation. The intake of macro and micro elements decrease with increasing dehydration but their absorption increases. (Mathur et al 1994).

Further studies on mineral requirements of dry, pregnant, lactating and growing camels suggested sodium supplementation in dry, magnesium in pregnant and higher levels of zinc and manganese in lactating and growing baby camels (Nagpal 1992).

From the foregoing accounts, it could be concluded that requirements suggested for various categories of camel are still need to e updated. The pack and racing camels could be maintained on nut 1-ient supply from leguminous stl-aws with other insufficient conventional natural flora. But the draft camels used for heavy work such as ploughing and pulling oad need definite supplementation by including concentrate in their diets to keep them in a fit condition. Attempts should be made to formulate least cost balanced rations with inclusion of non-conventional feeds to make the ration effective and economical for working camels.

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DIAGNOSTIC APPROACH FOR THE LIVESTOCK AFFECTED DROUGHT SITUATION

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As it is open fact that this part of the western part of the Rajasthan remains one of the most drought affected area. In spite of this fact this is also a fact that Animal husbandry remains the main source of lively hood. This area is also home ground for some of the best breeds of cattle, goat, sheep camel & Horse in this nation. In local sayings also it is said that there is only one bumper crop one in 4-5 years. The literary meaning of the word MARWAR also means ejus okyks dh txg -- the land of "Warriors"

So it becomes all the more important from animal husbandry point of view that what are commonly prevailing diseases present & their timely diagnosis & confirmation to conserve the live stock & sustain the livings in drought period.

So diagnostic approaches for the livestock affected during draught situation can be mainly classified under five following headings about which each are details thereafter.

- Deficiency diseases due to nutritional stress i.e., deficiency of vit A, Phosphorus, Copper,Magnesium,Cobalt,Calcium.
- Poisoning-- Like nitrate, cyanide, aflatorius, urea-molleses,Lantana, other miscellanies vegetative.
- Indigestion-- Alkalosis, Acidosis, constipation diarrheas, PICA & botulism.
- Physical factors -- Heat strokes, dehydration, & epidemiologic indications cold & pneumonia etc.
- Loss of Immunity -- primarily due to above factor & extreme climatic conditions due to opportunistic nature of infection micro-organizes whether they may be Bacterial / Viral / protozoa/ Fungal / clam dial / Rikketrial / Ecto parasites / Endo parasites etc.

Mal nutrition of nutritional errors during drought period production disease adversely affects

Acetonemia in cattle, Pregnancy toxemia in sheep.
Etiology:- A multi factorial disorder of energy metabolism.
Negative energy to hypoglycemia and ketonemia(accumulation in blood of acetoacetate, beta-hydroxybutyrate and their decarboxylation product acetone and isopropanol)
The disease in cattle and sheep occur I different part of the pregnancy-lactation cycle.
Epidemiology:- Primary ketosis occur in well conditioned cows with high lactation potential, principally in the first month of lactation with a higher prevalence in cows with higher lactation number.
Secondary ketosis occur where other disease reduce feed intake.
The disease in sheep is associated with a falling plane of nutrition. Principally in the last month of pregnancy in ewes bearing twins and triplets but can be induced by other stress at this time.

signs:- Cattle show wasting with decrease appetite
Fall in body condition as milk production, Neurological sign.
Sheep encephalopathy with blindness muscle tremor, convulsion, metabolic acidosis.
Clinical pathology:- Hypoglycemia, ketonemia, ketourea or elevated ketones in milk.
Necropsy finding:- Non specific, Twin lambs and fatty liver.
Diagnostic confermation:- Ketonimia, Ketonurea elevated beta hydroxy butyrate(BHBA) in aqueous humor of dead sheep.
Disease cause by deficiency of vitamin 'A'

Etiology:- Dietary deficiency of vit A or its precursors.
Epidemiology:- Common in cattle grazing dry pastures for long periods.
Occur when diet of hand fed animals is not supplemented with vit A.
Signs cattle:- Night blindness, loss of body wt., convulsions followed by recovery. Permanent blindness with dilated pupils and optic disc edema.

Pig:- Convulsion, hind leg paralysis. Congenital defects.
Clinical pathology:- Low level plasma vit A
Lesions:- Squamous metaplasia of inter lobular duck of parotid gland. Compression of optic nerve track and spinal nerve root. Degenerations of testes.
Diagnostic confirmation:- Low level of plasma vit A and squamous metaplasia of interlobular duct of parotid glands.

Mineral Deficiency

1. Calcium:-
   Etiology:-Primary dietary deficiency of calcium uncommon sec. ca. def. due to marginal calcium intake and high P intake.
   Epidemiology:- Sporadic, Not common if diet adequate.
   Signs:- Poor growth and dentition. Tetany may occur in lactating ewes. Inappetance, stiffness, fracture of long bones.
   Clinical pathology:- Serum cal. P. and radiography.
   Lesions:- Osteoporosis, low ash content of bone.
   Diagnostic confirmation:- Histology of bone and bone ash analysis.

2. **Phosphorus**:-
   Etiology:- usually a primary deficiency in diet, may be conditioned by vit D deficiency.
   Epidemiology:-Primary P def. occurs world wide. Soils and crops commonly deficient in phosphorus.
   Primary deficiency may occur in lactating dairy cattle in early lactation.
   Occurs under range conditions in beef cattle and sheep.

*Sign:- **Young animals grows slowly, develop rickets. Adults develop ostomalacia, unthriftiness, wt. loss, reduce feed consumption, reluctance to move, factures, impaired fertility.***
*Clinical pathology:- **Serum P, P-content of diet***
*Lesions:- **Rickets and osteomalacia, lack of mineralization of bones.***
*Diagnostic confirmation:- **Histology of bone and bone ash analysis.***

Cobalt:-

Etiology:- Dietary deficiency of co resulting in a deficiency of vit B_{12}
Epidemiology:- Occurs primarily in cattle and sheep unsupplemented with co. World wide where soils are deficient in co. Associates with ovine white liver disease.
Sign:- Inappetance, gradual loss of b. wt. pica marked pallor of the m.m., wool and milk production decreases, decreasing lambing %
Clinical pathology:- Co. or vit B12 conc. of liver, Co. Conc. methylmalonic acid in plasma and urine. Formiminoglutamic acid in urine, anemia.
Lesion:- Emacialtion, nemosiderosis of spleen.
Diagnostic confirmation:-Vit B12 and co. of liver.

4. Copper:-

Etiology:- Primary cu def. due to inadequate levels in diet. Sec.Cu.def. due to conditioning factor such as excess Mo.and sulfur in diet.

Epidemiology:- Primary in young pastures ruminants in spring and summer. Primary def. occurs in sandy soils and heavily weathered areas. Feed water supplies may contains Mo. sulfate, and iron salts which interfere with Cu. metabolism.

Sign:- Unthrift ness, change in hair colour chronic diarrhea, chronic lameness, neonatal ataxia, anemia, enlarge hoof,

Clinical pathology:- Low serum and hepatic cu. Ceruloplasmin anemia.

Lesions:- Anemia, emaciation, hemosiderosis, osteodystrophy, myocardiopathy, demyelination in enzootic ataxia.

Diagnostic confirmation:- low serum and hepatic cu and response to treatment.

3. **Magnesium(Hypomagnesaemia tetany)**

Etiology:- Hypomagnesaemia resulting from in adequate Mg.in diet.

Epidemiology:- Most commonly calves 2-4 month of age, on whole milk or milk replaces diets and poor no roughage, diarrhea and chewing bedding or other coarse fiber may exacerbate the def.

Sign:- Apperherision, Agitation, hypersensitivity to all external stimuli, fine muscle tremors progressing to spasticity nd violent convulsions. Rapid course and high C.F.R.

Clinical pathology:- Serum Mg. levels below 0.8 Mg./dl,(Normal2-2.5 Mg./dl) bone Ca:Mg. ratio above 90:1(Normal 55:1)

Necropsy finding:- Calcification of the spleen, diaphragm and endothelium of the arota and endocardium.

Diagnostic confirmation:- Blood Mg. and response to treatment. Bone Ca:Mg. ratio.

Disease causes by major phytotoxins

Cyanogenic glycoside poisoning(HCN poisoning):-

Etiology:- Ingestion of specific plant species containing cyanogenic glycoside

Epidimiology:- Seasonal and other variations in glucoside content lead to periods of enhanced toxicity of pasture.

Sign:- Acute poisoning soon after access to toxic material sudden onset of dyspnea, tremor, recumbency, convulsions, death within a few min. to hour.

Chronic poisoning:- Neonatal goiter or arthrogryposis, adult:- in coordination, dysuria, frequent urination.

Clinical pathology:- Assay of HCN in body tissuses and fluids and in feed.

Necropsy finding:- Bitter almond smell opening of carcass.

Diagnostic confirmation:- Positive assay of rumen content.

Jodhpur:- Banar,

Pali city, Jalore,

Nitrate and nitrite poisoning

Etiology:- Nitrate As Na, K Nitrate fertilizer, food preservative. Nitrite performed in nitrate rich, moldy plant material or as nitrate converted in rumen in nitrite.

Epidemiology:- Outbreaks due to access to abnormal materials. Hay or any plant growing profusely after a long drought or high nitrate contents soil.

Sing:- Sudden on set of severe dyspnea, brown mucosae and blood, short course, high C.F.R.

Clinical pathology:- Very high blood level of methemoglobin(9g/100 ml blood-lethal level)

Necropsy finding:- Brown blood in some.

Diagnostic confirmation:- Positive assay for nitrite in feed, blood or aquous humor .

Field test:-A simple test "**Diphenylamine Blue Test**" is available for detecting nitrate in feed/urine/blood/rumen content samples.

JAISALMER VILLAGE SALKHA (SUM)

JODHPUR VILLAGE:- Sir, Aaktheli (LUNI)

SHEEP MOTILITY 464.

Urea:- M. common during drought by feeding urea treated fodder- excessively or accidentally.
cl. symptoms:- 1. Abdominal pain. 2. Muscle tremors & in coordination. 3. Blood oozes out from orifices. 4. Senero struggling & bellowing death.

Sample in living:- 1. Blood & serum.

P.M.L. & Samples:- 1. Hemorrhages over heart. 2. Bright red colour undotted blood.3. Congestion of liver spleen, kidney.

Pm samples:- 1. ingesta- Intestine at both ends, pieces of liner, kidney, spleen, Is-slides.

Treatment - 2% acetic acid solution.

JODHPUR DHUNDHADA (LUNI)

Disease due to inorganic poisoning

Fluoride:- Source- 1. Old wells in use only during draught water is elixir of life but unfortunately This arid region faces the problem of quantity ass well quality of water. In endemic areas of barmer, jalore, sikar, dungarpur, & other arid districts showed the evidence of skeletal flurasis the highest prevalence of 60 % was observed at 8.0 mg/l fluoride

Cl. symptoms:- As a result of discoloration the teeth of animals became weak & rough, loss of appetite, stiffness of bones, lameness are common and with this poor nutritional status of animals further aggravates the susceptibility.

Samples in living:- 1. Drinking water sample.
2. Blood & serum.

PML & Samples:- Depending upon the amount of fluorine ingested, affected teeth & bones appears with characteristical "Mottling" which indicates hypoplazia, hypo calcification, staining & abrasion. The must charteristic lesions are osteoporosis, exostosis of long bones & mandibular bones besides increase in osteoid tissue. Therapeutically

1. Aluminum sulfate 30 gm orally
2. ca salt 9/v.

Jalore, Barmer,Balotra

INDIGESTION & METABOLIC diseases like ketosis develops during draught due to malnutrition poor nutrition. Due to this various affection develops like altcalasis, acidosis, tympany / bloat constipations

Alkalosis results from overfeeding per or quality of roughages. Where as **acidosis** develops due to overfeeding of grains concentrates. The best way to diagnosis besides this history is t examine ruminal. PH , Blood ph & thereby correct it. Blood /urine chemistry can easily diagnose it.

Here I will like to take in the PICA & botulism also which are predisposed in draught due malnutrition & deficiency of vit. / Minerals in botulism besides history, blood serum samples Gastric leverage / wash can be of useful diagnostic technique to identify the presence of its.

Physical Factors & i.e. heat strokes, cold Epidemiological Indicators (due to desert like climate) dehydration these affections can be diagnosed easily besides history & epidemiological indicators for correct diagnosis equiblrium of different blood fluid electrolytes can be chequed & corrected. For cold exposure & influenza routine blood picture will prove to be sufficiently effective.

Loss of immunity:- Nutritional deficiencies & extreme climatic condition during draught leads to such a stressful condition, that all the infections micro organisms becomes opportunistically aggressive & aggravate the diseases. The main culprit here is the drought, which plays the role of catalysts & predisposes the animal to various diseases.(Ex. F.M.D., P.P.R., Sheep pox, Calf scour, C.C.P.P., B.Q., H.S., E.T., Brucellosis, T.B., Jonin disease)

As far as **Ecto parasites(Ticks & mits)** are concerned the skin scrapings can be taken for lab. examination & confirmation. Here important point which is to be kept in mind that on the surface of scalp blade/knife wax is to be applied & skin is sufficiently cut in depth so as to ensure the inclusion of parasites from their Burroughs made semitones deep in skin.

(Tryps,Babesisosis, Thellaria,Anaplasma)

As regards to **endo parasites** their can be best choice that is feacal examination. small amount of faces say 5-10 gm may be taken for examination. But as far as samples from dead animal are concerned they may be taken during post- mortem. eg. intestine, cysts different larval route & stages during their lung, liver etc.

As far as **fungal infection** disease concerned of lesions on skin is resent like in ring worms then skin scrapings are to taken. For lab examination & confirmation wood lamp testing lab is confirmatory for this, another very good diagnostic too for an spot diagnosis from field point of view can be a swab soaked in chloroform to applied on skin lesion. If colour changes to white then it indicates for fungal infection.

As far as fungal infection of genitals is concerned then the swab soaked in situ discharges may be collected & sent to lab for its diagnosis & confirmation. In lab they can be cultured & isolated--identified.

Like wise milk from affected quarter in mastitis can be collected & sent to lab. Like wise urine for urogenital infection and nasal or ocular discharges from simultaneous infections can be collected & sent to lab for isolation, identification & sensitivity tests. Bacterial isolation & mycoplasma identification.

EXTENSION INTERVENTIONS IN TRANSFER OF ANIMAL HUSBANDRY TECHNOLOGIES RELEVANT TO DROUGHT PRONE AREAS

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India is characterized by drylands/rainfed areas that constitute about 70 percent of the available land. This vast rainfed/dryland/drought prone areas contribute 42 % of food grains and about 75 % of pulses and oilseeds. Out of total 588 rural districts, about 128 districts of the country fall in low to medium rainfall zone. Majority of these rainfed districts face great instability in crop production due to erratic and inadequate rainfall, further recurrence of drought every after 2 to 3 years is a common phenomenon. In this situation of uncertainities in agricultural production in rainfed farming, livestock production is appreciated to provide sustainability and economic stability to the farmers. Consequently, livestock production has been adopted by the farmers of these problem areas to augment and stabilize their additional income. Further, in these areas, crop residues are abundantly available to supplement the feeding of their livestock. Hence, role of livestock production in drought prone or rainfed areas is manifold and due importance needs to be given to augment its development programmes in the areas.

The some location specific studies in these areas have revealed the effectiveness of livestock farming to supplement the income of the farmers. Further, the production and productivity of bovines, sheep and goat, poultry and duckery as well as of aquaculture etc. in different agro-climatic conditions are most encouraging for generating additional income of the poor farming community. Livestock is a rapidly growing sector of Indian economy. It contributes 5.22 % of Indian GDP and 28 % value of output of agriculture and allied sector. The country is well endowed with livestock population (cattle-185 mil, Buffalo-99 mil, Sheep -62 mil, Goats- 120 mil, Pig- 15 mil and equine -12 mil). India is the highest producer of milk with 91 mil tonnes. Milk production has grown @ 3.4 % in last few years and productivity has grown @ 2.6 % in last 10 years. The productivity of milch animal is 987 kg per year as compared to world average of 2200 kg/year and per capita availability of milk is 231 gm/day as compared to world average of 270 gm/day. The value of milk output and its products is 70,000 crore rupees and that of dairy industry as whole is 1,05,000 crore rupees. The small ruminants in these areas are very important species of livestock playing important role in national economy. In rainfed areas, this livestock enterprise is advantageous due to their short generation intervals, higher rates of proficiency and the ease with which they can be marked for meat, milk, skins and wool. This enterprise is associated with social and cultural fabric of millions of resource poor of the hilly and dry land areas. These small ruminants are very useful in semi-arid and arid zones where they can sustain themselves on sparce vegetation and extreme climatic conditions. Early sexual maturity, low age at first kidding (10-14 months) and multiple births in goat and sheep are the factors contributing to a rapid rise, specially in goatery.

Some facts of rainfed agriculture and livestock production.

The two states of ICAR Zone VI comprising of Rajasthan and Gujarat fall under low rainfall and low irrigation group based on average annual rainfall and % irrigated cropped area :-

Particular		Rajasthan	Gujarat
# Average annual rainfall(mm)		494.	877
# Percent irrigated cropped area		21.30	28.89
# Livestock population (in '000)			
(For 1982)	Cattle	13505	6994
	Buffalo	6043	4443
	Goat	15479	3300

Sheep	13431	2357
Total livestock	49651	17468
# Livestock Density		
(Heads/100 ha cropped area) (1982)		
Cattle	73	64
Buffalo	33	41
Goat	84	80
Sheep	73	22
Total livestock	270	160
# Growth rate in Breedable cows (1956-82)	0.25	0.23
# Growth rate in Breedable buffaloes "	2.10	1.93
# Growth rate in young stock - Cattle "	0.27	0.15
Growth rate in young stock - Buffalo "	1.90	1.58
# Yield per animal in milk (kg/day) Cow(1986-87)	2.720	2.599
" Buffalo	3.850	3.561
# Milk production ('000 tones)(1987-88)	4000	2997
# Per capita per day milk availability (gm) (1987-88)	270	213
#Growth rate in milk Production(%)	3.70	5.11
#Percent area under fodder crops to total cropped area	14.15	9.32
#Percent irrigated area under fodder crops	9.82	12.53
#Permanent pastures and other grazing land to	10.15	8.75
Total cropped area		
#Annual feeds and fodder availability during 1988-89 Green Fodder	70450*	25375*
*refers to 1985-86 Sugarcane Tops	69	791
Dry fodder	16512	8974
Oil seed cakes	1372	2613
Total Bran	246	130
#Fodder and feeds availability for bovines		
(Per capita/day) – 1988-89(grams)		
-Green Fodder	9134	5633
-Sugarcane Tops	8	175
-Dry Fodder	2143	1992
-Oilseed cakes	203	132
Total bran	30	28
#Density of livestock population		
-Per ha of cropped area	7.31	5.77
-Per ha of geographical area	3.70	3.28
-Area/head	1.44	0.51

Arid (Low rainfall) and Semi-arid (Medium rainfall) areas are characterized for mono-cropping, mixed farming system with low value crops, grazing animals as well as cut and carry grass/fodder to feed it to their livestock. The efforts are being made to transfer relevant technologies to the farmers of these areas, however, response is not satisfactory because of the constraints in livestock rearing such as low productivity, poor health and infectious diseases, less availability of feed and fodder, inconsistent breeding policies, a huge unproductive stock and restricted market access. The factors contributing to low productivity in animals are – a very slow rate of increase in population growth of crossbred animals, i.e.19 % of total population, non-availability of quality semen and/or breeding bull, poor conception rate following AI, lack of policy initiative, scarcity of land for fodder cultivation, high feed deficits and lack of capital investments.

Technical and extension interventions needed

Undoubtedly, in drought prone areas, livestock sustains poor farmers in case of natural calamities. Therefore such calamity proof technologies for sustaining animal husbandry need to be evolved. Such suitable technologies could be related to clean milk production, rearing of healthy calves, disease prevention, optimum nutrition, enhancing the quality of dry fodder, storage of products, maintaining productivity during calamities, better reproductive efficiencies in animal etc. We need to have package of practices specific to locale and clients. Some of these technologies are available but have not reached to farmers. Thus evolving region specific technologies assumes significant importance in these areas. Documentation, screening and preparing compendium of technologies is required. Further, many technological innovations require to be delivered at the farmer's door step, eg. AI service, vaccination, therapeutics – etc, accordingly extension approaches are to be followed. These is also need to recognize innovations by farmers and also to document their indigenous technical knowledge related to animal husbandry and wherever necessary validate the same and blend with modern technologies for wider acceptance. There is also a need of having interface between progressive farmers and farmers in general of these areas for efficient propagation of technologies. Therefore, there is a need to re-structure the technology dissemination from individual to collective, particularly in drought prone areas because common property resources and open access resources play a major role in animal husbandry practices.

The importance of animal husbandry is not often adequately reflected. The lessons learnt from earlier programmes reveal that true potential of Indian farmers is realized through operation flood which is the classic example of fusion between technological intervention and linkage with end users. Further, innovative technologies have the potential to revamp the growth of animal husbandry. It is also to be noted that technologies not suitable for small holder system are unlikely to gain wider acceptance. For appropriate extension interventions, resources, skills and opportunities of target groups need to be understood and analyzed in true perspective. A fresh and exclusive animal husbandry extension infrastructure is required involving state animal husbandry department, existing KVKs, NGOs, Private Industries and Farmers.

The lessons learnt through implementing several field extension education programmes at Indian Veterinary Research Institute, Izatnagar suggest for comprehensive programme in animal husbandry targeted towards livestock owners. The list of activities could be manifold, however, notable could be like organizing animal health-cum-production camps wherein cases of clinical, gyanecological and surgical nature are treated by the scientists with close collaboration of field veterinarians; organizing deworming and mass vaccination campaigns with support of state animal husbandry departments, NGOs, :Private Industries (Pharmaceuticals) and farmers; conducting joint diagnostic surveys for better animal health, organizing interface between scientists, field veterinarians and farmers, conducting demonstrations in livestock enterprise and on-farm-testing for providing better technological options and also for refinement of technologies involving scientists of research system, KVKs subject matter specialists and livestock owners; imparting training to livestock owners, farm women and rural youth on relevant package of practices in animal husbandry with emphasis to undertake an economic activity, provision of farm literature and use of mass media for educating livestock owners about improved animal husbandry technologies. Concerted efforts by all concerned in the development of animal husbandry certainly will pave a way in enhancing production and productivity in animal husbandry and in harnessing the benefits at large by the farming community, more particularly by the resources poor of less endowed areas.

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ANIMAL INSURANCE -A FINANCIAL SAFEGUARD TO LIVESTOCK OWNERS DURING NATURAL CALAMITIES

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What is Insurance: The business of insurance is related to the protection of the economic value of the assets. Every asset has a value and on untimely loss through an accident or misfortune event, the owner suffers. Insurance is a mechanism that helps to reduce such adverse consequences.
Purpose & Need of Insurance : Assets are insured because they are likely to be destroyed or made non-functional through an accidental occurrence which may or may not happen. There has to be an uncertainty about the risk otherwise is not insurable. Insurance does neither protect the asset nor prevent its loss due to the peril (e.g. accident, flood, earthquake, etc.). Insurance compensates the losses which may not be full compensation depending upon type of policy. Only economic or financial losses can be compensated. Insurance covers tangible and intangible assets (e.g. voice of singer).

Thus the purpose of insurance is to safeguard against such misfortunes by making good the losses of the unfortunate few. Thus insurance is a economic and social security tool.

Contract of Insurance: When the insured pays the premium and the insurer accept the risk, the contract of insurance is concluded. The policy issued by the insurer is the evidence of contract.

The insured pays premium and insurer "promises to indemnify" as per the terms and condition of policy. The person to the contract should be competent to contract and object of the contract must be legal and not against public policy. In insurance contract "utmost good faith" is to be observed, which means insured has a legal duty to disclose all material information about the subject matter of insurance to the insurers, who do not have this information.

Who can Insure: If the person is likely to suffer financially when the property is lost or damaged, he has insurable interest and can insure that property. The insurable interest may be by way of ownership or as financer or as tenant etc. and it should be present both at the commencement of insurance and at the time of loss.

Indemnity: The principle of indemnity arises under common law and requires that an insurance contract should be a contract of indemnity only and nothing more. The object of the principle is to place the insured after a loss in the same financial position as far as possible, as he occupied immediately before loss. The effect of this principle is to prevent the insured from making a profit out of this loss or gaining any benefit or advantage.

The object of a contract of insurance is o protect the financial interest of the insured in the subject matter of insurance. If the insured could recover any amount in excess of his loss, he would make a profit, and if this is permitted, there may be a temptation for the insured himself to bring about the losses so as to make a profit. This would be against public policy.

The measure of indemnity for loss of or damage to the insured property is generally the intrinsic market value of the property at the place and on the date of loss or damage.

Rural Insurance: The rural population of India is dependent on agriculture and animal husbandry. The losses to crops or livestock are beyond the capacity of rural poor to bear.

Obligation of Insurers to the Rural Sector : Keeping in view this fact Section 32 B & 32 C of the insurance Act 1938 states that insurers are obliged to underwrite 2%, 3% and 5% of total gross premium in the first, second and third year onward, the business in the rural sector including insurance for crops.

The rural sector has been defined as any place which as per the last census, has a population not more than 5000, density of population not more than 400 per square KM and at least 75 % of the male working population engaged in agriculture.

Rural Policies : Rural policies comprise insurance of :-

Livestock - e.g. cattle, sheep, goat, camel etc.

Various food crops - cereals, millets, pulses, oilseeds, cottonseeds, sugarcane, Potato, etc. This done by the Agriculture Insurance Company.

Plantation and Horticultural crops – e.g. rubber, grapes, etc.

Floriculture

Property - e.g. agriculture pumpsets, tractors, etc.

Persons - e.g. Janta and Gramin personal Accident

Sub-animals – e.g. silkworm, honeybee, brackish water prawn, etc.

The Role of Government : The Govt. of India have launched various programmes for the benefit of small farmers, marginal farmers, agricultural labourers, etc.Since 1980 all these schemes were integrated into Integrated Rural Development Programme (IRDP) funded by Central & state Govts.

Special insurance schemes are framed to protect the beneficiaries of IRDP Projects. Under these policies, the rates of premium are lower and claim Procedure is simplified. Whenever the word 'scheme' is used hereafter, it refers to these special policies.

THE HIGHLIGHT OF CATTLE INSURANCE:-

Cattle Insurance

Bottom of Form

- Highlights
- Insurance Coverage
- Major Exclusions
- Documents to Effect Insurance Coverage
- Identification of Animal
- Claim Procedure

Highlights

This scheme covers the following whether indigenous, exotic or cross-bred .

Milch Cows and Buffaloes

Calves / Heifers

Stud Bulls

Bullocks (Castrated Bulls) and Castrated Male Buffaloes,

Animals within a specified age group are accepted under the Standard Insurance Scheme.

Sum Insured under the policy will be the Market Value of the animal.

Indemnity under the policy will be the sum insured or market value prior to illness whichever is less. The indemnity is limited to 75% of Sum Insured in case of a PTD claim.

The basic premium rate per annum is 4% of the Sum Insured. Long term policies are also issued with long term discounts.

The premium rates under the policy are concessional for covering animals under government subsidized schemes.

Group Discounts are also available.

Insurance Coverage

The policy shall give indemnity for death due to.

Accident (Inclusive of fire, lightning, flood, inundation, storm, hurricane, earthquake, cyclone, tornado, tempest and famine).

Diseases contracted or occurring during the period of this policy.

Surgical Operations.
Riot and Strike.
The Policy can also be extended to cover PTD on payment of extra premium;
Permanent Total Disability which, in the case of Milch Cattle result in permanent and total incapacity to conceive or yield milk.
PTD which in the case of Stud Bulls results in permanent and total incapacity for breeding purpose.
In case of Bullocks, Calves / Heifers and Castrated male buffaloes results in permanent and total incapacity for the purpose of use mentioned in the proposal form.

Major Exclusions

(A) Common Exclusions:
Malicious or willful injury or neglect, overloading, unskillful treatment or use of animal for purpose other than stated in the policy without the consent of the Company in writing.
Accidents occurring and /or Disease contracted prior to commencement of risk.
Intentional slaughter of the animal except in cases where destruction is necessary to terminate incurable suffering on humane consideration on the basis of certificate issued by qualified Veterinarian or in cases where destruction is resorted to by the order of lawfully constituted authority.
Theft and clandestine sale of the insured animal.
War, invasion, act of foreign enemy, hostilities (whether war be declared or not), civil war, rebellion, revolution, insurrection, mutiny, tumult, military or usurped power or any consequences thereof or attempt threat.
Any accident, loss, destruction, damage or legal liability directly or indirectly caused by or contributed to by or arising from nuclear weapons.
Consequential loss of whatsoever nature.
Transport by air and sea.
Any non-scheme claim arising due to diseases contracted within 15 days from the date of risk are not covered.
(B) Specific Exclusions :
Pleuropneumonia in respect of Cattle in Lakhimpur and Sibasagar Districts and newly carved out districts out of these two districts of Assam.
All the claims received without ear tag.

Documents to Effect Insurance Coverage

Proposal Form
Veterinary Health Certificate from a qualified Veterinarian giving the age, identification marks, health, and market value of the animal in the prescribed format.

Identification of Animal

All insured animals should be suitably identified by natural Identification marks and color should be clearly noted in the proposal form and Veterinarian's Report.
Ear tags made of suitable material are applied to the ear of the animals and the code number is entered into the Veterinary Health Certificate.
Photographs of animals may be insisted in case of high value animal.

[redacted]

Complete chart of treatment, medicines used, receipts, etc., should be submitted.
Admissibility of claim will be considered after two months of Veterinary Doctor / Company Doctor's report.
The indemnity is limited to 75% of Sum Insured.

Insurance: provides safeguards and financial support in case of live stock died or disabled through an accident or illness or natural calamities. Thus the purpose of insurance is to safeguard against such misfortunes by making good the losses of the unfortunate few. Thus insurance is a economic and social security tool

Sheep & Goat Insurance
Bottom of Form

- Highlights
- Scope
- Exclusion
- Sum Insured
- Claim Procedure

Highlights

All indigenous, crossbred and exotic Sheep and Goat will be covered under this Scheme.

Scope

The policy shall provide indemnity against death of sheep and goats due to accident Including Fire, Lightning, Flood, Cyclone, Famine, Earthquake, landslide, Strike, Riot or diseases contracted or occurring during the period of insurance.

Exclusion

Common Exclusion
Malicious or willful injury or neglect, overloading, unskillful treatment or use of animal for purpose other than stated in the policy without the consent of the Company in writing.
Accidents occurring and /or Disease contracted prior to commencement of risk.
Intentional slaughter of the animal except in cases where destruction is necessary to terminate incurable suffering on humane consideration on the basis of certificate issued by qualified Veterinarian or in cases where destruction is resorted to by the order of lawfully constituted authority.
Theft and clandestine sale of the insured animal.
War, invasion, act of foreign enemy, hostilities (whether war be declared or not), civil war, rebellion, revolution, insurrection, mutiny, tumult, military or usurped power or any consequences thereof or attempt threat.
Any accident, loss, destruction, damage or legal liability directly or indirectly caused by or contributed to by or arising from nuclear weapons.
Consequential loss of whatsoever nature.
Transport by air and sea.
Any non-scheme claim arising due to diseases contracted within 15 days from the date of risk are not covered.
Specific Exclusion
Enterotoxaemia, Sheep Pox, Goat Pox, Rinderpest, FMD, Anthrax, H.S, B.Q. These diseases are covered by the policy if the animal is successfully inoculated (protected) and necessary Veterinary Certificates are supplied to the Company.

Sum Insured

The market value of sheep and goats varies from breed to breed, from area to area and from time to time. The examining Veterinarians recommendations shall be considered as the proper guide for acceptance of insurance as

well as for settlement of claims.
Sum insured will not exceed 100% of market value.

Claim Procedure

In the event of death immediate intimation should be given to the Company and the Insured should furnish the following documents and required information.
Duly completed claim form.
Death certificate from a Veterinarian on Company's form.
Post mortem examination report if required by the Company.
Ear tag wherever applicable.

LIST OF OTHER POLICIES WHICH ARE BENEFICIAL TO THE RURAL MASSES:-

Cattle Insurance

Sheep & Goat Insurance

Horse / Pony / Mule / Donkey Insurance

Pig Insurance Scheme

Camel Insurance

Poultry Insurance Scheme

Duck Insurance Scheme

Rabbit Insurance Scheme

Elephant Insurance Scheme

Dog Insurance Scheme

Zoo And Circus Animal Insurance Scheme

Inland Fish Insurance Scheme

Silk Worm Insurance Scheme

Honey Bee Insurance

Agricultural Pumpsets Insurance Scheme

Animal Driven Cart Insurance

Hut Insurance

Gobar Gas Insurance Scheme

Lift Irrigation Insurance

Janata Personal Accident

Gramin Personal Accident Policy

Composite Package For Tribals

Farmers Package Insurance Scheme

Horticulture / Plantation Insurance

Comprehensive Floriculture Insurance

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