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Fodder Strategy for Sustainable Animal Production in Arid Rajasthan

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Abstract: Forage and feeds are the major inputs in animal husbandry, which constitute nearly 70% of the total cost of production. Cultivated fodders, including dual purpose crops, residue of field crops, rangelands and pastures, fodder trees and shrubs, etc. are multiple sources of fodder for animals in arid Rajasthan. For sustainable animal production, the improved cultivation and management practices of all these fodder resources along with fodder conservation and utilization strategy need to be developed in arid Rajasthan.

Key words: Cultivated fodder crops, dual purpose crops, pasture grasses, trees and shrubs.

Crop production and animal husbandry go hand in hand for resource conservation and their utilization for sustainable agriculture in arid Rajasthan. Adverse climatic conditions like low and erratic rainfall, frequent droughts, high temperature, speedy winds, high evapo-transpiration and poor water resources are the major constraints for crop production in arid zone (Venkateshwarlu, 2004). Animal rearing matches the potential and limitations of natural resource base in these areas. Cattle, buffalo, sheep, goat and camel are indispensible and generate income and employment for livelihood support for rural families.

Animal husbandry in arid Rajasthan is mainly dependent on rangelands and pastures, fodder trees and shrubs, and crop residues. Presently, the grazing resources of arid Rajasthan are shrinking and their grazing capacity has also declined due to un-judicious utilization and high grazing pressure. However, the availability of nutritious fodder is essential for animal health and production. Now, there is an urgent need to augment fodder production planting high yielding fodder varieties and adopting improved crop management practices, pasture improvement adopting technological interventions and plantation of trees and shrubs to establish green fodder bank for sustainable livestock production (Sharma, 2001; 2006).

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Cultivated Fodder Crops

High yielding varieties of cultivated fodder crops for arid Rajasthan

The fodder crop improvement program of ICAR, along with State Agricultural Universities, has developed many potential varieties of fodder crops for different agro-ecological situations of arid and semi-arid regions of India. The newly developed varieties are superior in yield under a particular situation. The fodder quality, including nutritive value, digestibility and palatability of these varieties is also better over obsolete varieties. Some high yielding varieties of cultivated fodder crops identified for arid Rajasthan are given in Table 1 (Sharma, 2012).

Important dual purpose crops and their suitable varieties

There are certain crops which are valued for grain as well as fodder and therefore categorized as dual purpose crops. In the present scenario of fragmented and small land holdings, breeding efforts are going on to develop high yielding varieties of dual purpose crops, so that farmer can get green fodder and food grain from the crops in the same season from the same piece of land. Pearl millet, sorghum and barley have excellent growth, biomass production and quick regeneration ability after cutting (Sharma, 2007; 2013 a & b). The potential of these crops has been recognized for dual purpose cultivation, where regenerated crop is managed for seed production after first fodder cut.

Table 1. High yielding varieties of cultivated fodder crops for arid Rajasthan

Fodder Crop	Significant varieties
Multi-cut pearl millet	Giant bajra, Raj bajra chari-2
Single-cut pearl millet	Raj-171, JBV-2, JBV-3, Pusa-266, AVKB-19
Multi-cut sorghum	CSH-24 MF, SSG-59-3, MP-chari, COFS-29, PC-6
Single-cut sorghum	SU-1080, Raj chari-1, Raj chari-2
Maize	Pratap makka chari-6, J-1006, African tall
Napier x bajra hybrid	APBN-1, CO-4, CO-3, PBN-233
Cowpea	Bundel lobia-1, UPC-9202, EC-4216
Clusterbean	HG-75, Bundel guar-2, Bundel guar-3, RGC-1031, RGC-986
Oat	RO-19, JHO-2000-4, JHO-851, OL-125, Kent, UPO-212, OS-6
Lucerne	Anand-2, Anand-3, RL-88
Berseem	Bundel berseem-2, Wardan, Miscavi
Methi	HFM-65, T-8
Mustard	Japanese rape, Chinese cabbage

Pearl millet is a dual purpose crop which provides stover for animals and grain for human consumption. Dual purpose pearl millet varieties identified for arid Rajasthan are Raj-171, JBV-2, JBV-3, Pusa-266 and Pusa composite-443. The grain and stover yields of different varieties of pearl millet obtained at ARS, Jalor, are given in Table 2.

Sorghum is a dual purpose crop which provides stover for animals and grain for human consumption. Dual purpose sorghum varieties identified for arid Rajasthan are CSV 15, CSV 20 and CSV 23. These varieties are not very good for grain production in arid Rajasthan because of their long duration. But under timely sown conditions and normal rainfall situation these varieties may be cultivated for dual purpose to meet the requirement of dry fodder as well as grain. However, under deficit rainfall and late sown situation these varieties may be harvested as fodder. Grain and undried stover yields of different varieties of sorghum obtained at ARS, Jalore are given in Table 3.

The barley varieties RD-2035, RD-2552, RD-2715 and Azad have been identified at national level for dual purpose cultivation. All four varieties have been evaluated in arid Rajasthan where fresh crop was harvested for green fodder at 50-55 days after sowing and regenerated crop was managed for grain production. The green fodder of barley varieties ranged between 21.6-24.0 t ha^{-1} and grain yield 2500-3200 kg ha^{-1}. Green fodder and grain yields of different varieties of barley obtained at ARS, Jalor are given in Table 4.

Table 2. Grain and stover yield of pearl millet varieties

Varieties	Grain yield (kg ha^{-1})				Stover yield (kg ha^{-1})			
	2007	2008	2010	Mean	2007	2008	2010	Mean
Raj-171	2807	2107	2904	2606	17780	12087	8617	12828
Pusa-383	2520	2033	2625	2393	12720	10780	7917	10472
JBV-2	2207	2740	2747	2565	18140	13533	7353	13009
JBV-3	2233	1743	3383	2453	18590	14200	12000	14930
ICMV-221	2100	2047	2363	2170	14747	9833	7203	10594
Pusa-266	2267	2537	2892	2565	17173	12540	8970	12894
ICTP-8203	1660	1947	1889	1832	8716	10987	6933	8879
CZP-9802	2273	2273	2253	2266	8240	8240	5364	7281
Pusa comp 443	-	-	3012	3012	-	-	9067	9067
Mean	2258	2178	2674	2429	14513	11525	8158	11106
CD (P=0.05)	377	375	515	-	2300	1403	1134	-

Table 3. Grain and stover yield of sorghum varieties

Varieties	Grain yield (kg ha^{-1})				Undried stover yield (kg ha^{-1})				Plant height (cm)
	2010	2011	2012	Mean	2010	2011	2012	Mean	
CSV 15	620	511	-	566	21915	26366	10500	19594	150.75
CSV 17	1269	2490	495	1880	14539	13118	6275	11311	128.75
CSV 20	470	364	-	417	29752	26573	11175	22500	151.00
CSV 23	083	222	-	153	26781	27990	10425	21732	135.00
PJ 1430	1068	712	-	890	17093	18833	6250	14059	112.00
Mean	702	860	-	781	22016	22576	8925	17839	135.5

Table 4. Green fodder and grain yield of barley varieties under dual purpose cultivation

Varieties	Green fodder yield (kg ha^{-1})				Grain yield of regenerated crop (kg ha^{-1})			
	2009-10	2010-11	2011-12	Mean	2009-10	2010-11	2011-12	Mean
RD-2035	28690	24573	13333	22199	1553	4215	3850	3206
RD-2552	30253	20517	14000	21590	1313	4398	3340	3017
RD-2715	27167	30807	13900	23958	1128	3538	2833	2500
Azad	33100	18630	13567	21766	1160	3932	3800	2964
Mean	29803	23632	13700	22378	1289	4021	3456	2922
CD (P=0.05)	2408	3141	2376	-	303	521	597	-

Mixed/intercropping of fodder cereals and legumes

Mixed/intercropping of cereals and legumes is a better crop management practice for providing the nutritive fodder to animals than sole cropping. A healthy cow of 400 kg body weight providing 7-8 L milk per day needs about 40 kg green fodder, which should contain about 20% dry matter and 13-14% crude protein to meet the nutritional requirement of the animal (Sharma, 2012). A combination of two-third cereals and one-third leguminous fodder is needed to meet out this requirement. Fodder productivity of some combinations of cereals and legumes obtained during kharif and rabi seasons at ARS, Jalor, is given in Tables 5 and 6, respectively.

Table 5. Green fodder yield of kharif cereals and legumes (Average of three years; 1997 to 1999)

Sole and intercropping of cereals and legumes	Green fodder yield (t ha^{-1})
Pearl millet	61.7
Pearl millet + cowpea	63.9
Pearl millet + clusterbean	61.0
Sorghum	53.1
Sorghum + cowpea	48.3
Sorghum + clusterbean	48.9
Maize	31.9
Maize + cowpea	37.2
Maize + clusterbean	33.5
Cowpea	23.5
Clusterbean	22.0

Fodder production under different crop sequences

Annual green fodder requirement of a milking cattle is about 15 t ha^{-1} throughout

Table 6. Green fodder yield of rabi cereals and legumes at 55-60 days after sowing (average of three years; 2000-01 to 2002-03)

Sole and intercrops	Green fodder yield (t ha^{-1})
Oat (OL-529)	27.6
Barley (RD-2052)	27.6
Intercropping of oat & pea (1:1 ratio)	23.4
Intercropping of oat & pea (2:1 ratio)	25.1
Intercropping of oat & mustard (1:1 ratio)	31.5
Intercropping of oat & mustard (2:1 ratio)	32.7
Mixed cropping of oat & pea (1:1 ratio)	27.9
Mixed cropping of oat & mustard (1:1 ratio)	33.4
Intercropping of barley & pea (1:1 ratio)	23.5
Intercropping of barley & pea (2:1 ratio)	24.2
Intercropping of barley & mustard (1:1 ratio)	30.8
Intercropping of barley & mustard (2:1 ratio)	31.5
Mixed cropping of barley & pea (1:1 ratio)	25.6
Mixed cropping of barley & mustard (1:1 ratio)	31.9

Table 7. Annual green fodder production of different crop sequences

Fodder crop sequence	Green fodder production (t ha^{-1})
Multi-cut pearl millet+cowpea - oat+mustard/barley+mustard	120-140
Multi-cut sorghum - oat+mustard/barley+mustard	110-130
Maize+cowpea - lucerne	90-100
Maize+cowpea - methi - maize+cowpea	70-100
Maize+cowpea - oat+mustard/barley+mustard - maize+cowpea	90-110
Single-cut pearl millet+cowpea/single-cut sorghum + cowpea - oat+mustard/ barley+mustard - maize+cowpea	110-130
Napier x pearl millet hybrid	100-120

year. The average green fodder productivity of different crop sequences at ARS, Jalor, is given in Table 7. Therefore, keeping the fodder requirement in view according to the number of animals and fodder productivity of different crop sequences in arid Rajasthan, annual fodder budget may be prepared.

Strategy for Rangeland and Pastures

In the past, *orans* and *gauchars* were demarcated and preserved by our ancestors as natural pasture for cow and other grazing animals. But now many of these lands have been either allocated by the Government and village *Panchayats* for other uses or encroached by the local people. Whatever natural pastures left are also not in a good condition due to lack of protection and high grazing pressure and un-judicious harvesting of trees for fuel and other domestic purposes by local people. Cropping pattern of arid zone has also been changed in the modern agriculture. Mechanization has deteriorated our natural grazing/browsing resources in general and sewan grass in particular. Strategy recommended for enhancing fodder production of rangeland and pasture is as under (Anonymous, 2012; Sharma *et al*, 1999):

i. All *orans* and *gauchars* available in the state need to be identified and documented, and their boundaries may be delineated by the Departments of Revenue and Forest, Government of Rajasthan. All policy measures should be adopted in future to stop allocation of these lands for non-grazing purposes.

ii. Most of the existing *orans, gauchars* and pasturelands need to revive and rejuvenate by planting suitable trees/shrubs and pasture grasses involving local people. Un-wanted bushes and weeds may be eradicated from these lands. Some norms and regulations may be fixed by the village Panchayat for judicious utilization of existing pastures.

iii. The natural habitat of Sewan grass in district Jaisalmer and its vicinity needs to be conserved. Sewan and lana are the best combination for grazing/browsing animals. Therefore, all possible efforts should be made for conservation and utilization of sewan and lana in these areas through collective community approach.

iv. Sewan-based agri-pasture in the form of alley cropping system may be promoted and popularized on cultivated lands in arid zone.

v. Efforts should be made to enhance seed production of grasses like sewn (*Lasiurus sindicus*), roondar dhaman (*Cenchrus ciliaris*), moda dhaman (*Cenchrus setigerus*) and karad (*Dichanthium annulatum*). Seed production under irrigated situation is an additional option for enhancing grass seed availability. In case of sewan and karad grass, where seed production and grass establishment is difficult, nursery raised seedlings and root slips may be used for their propagation.

Table 8. Important pasture grasses and their suitability under different agro-ecological situations

Name of pasture grasses	Seed rate (kg ha^{-1})	Suitable rainfall zone (mm)	Suitable habitat
Lasiurus sindicus (sewan)	7-8	150-350	Sandy, sand dunes
Cenchrus ciliaris (roondar dhaman)	5-6	250-750	Sandy, plains, sand dunes
Cenchrus setigerus (moda dhaman)	6-8	400-750	Sandy, plains, semi-rocky
Dichanthium annulatum (karad)	2.0-2.5	>400	Plains with heavy soils

vi. Rain water harvesting and conservation structures should be created in pasture lands. It would support plantation program and provide drinking water to grazing animals.
vii. Degraded lands affected by wind and water erosion or salinity and alkalinity, etc. may be improved for developing pasture and silvopasture on these lands.

Important pasture grasses suitable for different agro-ecological situations of arid Rajasthan are given in Table 8.

Trees/Shrubs as a Source of Fodder

Trees/shrubs are perennial fodder resources and classified as integral part of sheep and goat rearing and emergency feed for cattle. They help in augmenting natural resource base and provide range of products to agro-ecosystem. Therefore, it has been an integral part of farming system right from the ancient time to fulfil multiple needs of the society. Trees help in augmenting biodiversity, improve microclimate and support threatened microflora and fauna, animals and birds providing them forage, feed and habitat. They enhance soil fertility including macro and micronutrients and also help in sand dune stabilization (Hocking, 1993; Sharma, 2003; Sharma *et al.*, 2001). Strategy recommended for creation of live fodder bank through plantation in arid Rajasthan is as under:

i. Khejri (*Prosopis cineraria*) and bordi or jharberi (*Zizyiphus nummularia)* based traditional agro-forestry system must be strengthened in view of climate change for livelihood security and sustainable livestock production in arid zone. In mechanized agriculture, khejri and bordi may be planted on farm bunds and boundaries.
ii. Already planted trees/shrubs must be protected through community approach. All possible efforts should be made to create awareness and extension of scientific technology recommended for the control of drying khejri.
iii. Fodder trees and shrubs need to be planted on farm boundaries, along irrigation canals, road side, railway track, river bank; and forest and wastelands to create live fodder bank for sustainable livestock production and environmental security.
iv. Nurseries for production of quality saplings of top feed and multipurpose trees/shrubs may be establishment at each and every *Panchayat* level and be managed under MGNREGA. Nurseries of the Department of Forest, Universities, ICAR and ICFRE Institutes need to be strengthened. Besides that training and financial assistance may be given to private nursery owners for production of quality saplings.
v. Plantation and after care of saplings up to three years on *orans, gauchars,* along the road side and railway track, farm boundary of farmer fields and other common lands need to be undertaken at each and every *Panchayat* level under MGNREGA.
vi. Performance based incentive may be given to farmers and *gaushalas* to create their interest in plantation of trees/shrubs.
vii. Rain water harvesting and conservation structures may be created in the *orans, gauchars* and forest lands. It would support plantation program and provide drinking water to grazing animals.

Important fodder trees/shrubs suitable for different rainfall zone are given in Table 9.

Fodder conservation and utilization strategy for drought

Table 9. Important fodder trees and shrubs for different rainfall situations of Rajasthan

Tree/shrub	Suitable rainfall zone (mm)	Optimum plant geometry (m)	Green fodder yield/plant and availability after plantation	Utilization aspects
Khejri *(Prosopis cineraria)*	250-500	10 x 10	About 100 kg 8-10 years	• Considered best tree for agro-forestry in Rajasthan • May be planted on farm bund and boundary • Leaves locally known as loong are edible to all animals • Tender pods locally known as sangari is major constituent of famous Marwari vegetable Panchkuta • Fresh tender pods are used to prepare vegetable and mature dry pods, locally known as khoka, are relished by desert dwellers and animals

Tree/shrub	Suitable rainfall zone (mm)	Optimum plant geometry (m)	Green fodder yield/plant and availability after plantation	Utilization aspects
Anjan *(Hardwickia binata)*	400-750	10 x 10	20-25 kg 7-8 years	• May also be planted on farm bund and boundary • Very good plant for agroforestry • The wood has a timber value • Leaves are edible to sheep, goat and camel
Mopane *(Colophospermum mopane)*	250-500	8 x 8	5-7 kg 3-4 years	• Fast growing bush • Suitable for plantation on sandy and semi-rocky areas • Leaves are edible to sheep, goat and camel
Neem *(Azadirachta indica)*	350-1000	10 x 10	100-150 kg 6-7 years	• May also be planted on farm bund and boundary • Leaves are edible to all animals • Fruits and kernels are used in the preparation of organic pesticide
Ardu *(Ailanthus excelsa)*	400-800	10 x 10	100-150 kg 5-6 years	• May also be planted on farm bund and boundary • Leaves are edible to sheep, goat and camel • Fast growing and very good plant for agro-forestry • Has very high value for plywood industry
Nutan *(Dichrostachys nutans)*	250-450	1.0 x 5.0	8-10 kg leaves and 2-3 kg pods plant^{-1} 4-5 years	• May be planted on sandy, semi-rocky and rocky lands • Leaves and immature pods are edible to sheep, goat and camel • Spreads quickly through root suckers
Subabool *(Leucaena leucocephala)*	350-1000	1.0 x 5.0	20-25 2-3 years	• Fast growing tree. May be planted on moderately salt affected soils • Spreads very fast through seed • Leaves are edible to sheep, goat and camel
Israili Babool *Acacia tortilis*	150-500	8 x 8	20-30 kg 5-7 years	• May be planted on majority of degraded lands • Leaves and pods are edible to sheep, goat and camel
Deshi Babool *Acacia nilotica*	350-1000	10 x 10	50-60 kg 5-7 years	• May be planted on moderately saline soils • Leaves and immature pods are edible to sheep, goat and camel • Wood has timber value
Khajuri Babool *(Acacia nilotica var. cupresiformis)*	400-1000	6 x 6	20-25 kg 5-7 years	• Very good tree for agroforestry plantation • Leaves are edible to sheep, goat and camel • Wood has timber value
Kumat *(Acacia senegal)*	250-750	8 x 8	8-10 kg leaves 7-8 years	• Suitable for rocky and gravelly surface • Leaves are edible to sheep, goat and camel • Seed is a major constituent of Marwari vegetable Panchkuta • Also produces best quality gum in arid zone
Dhav *(Anogessus latifolia)*	400-750	10 x 10	8-10 kg 7-8 years	• Suitable for rocky and gravelly surface • Leaves are edible to sheep, goat and camel • Wood has very high value • Produces good quality gum also
Siris *(Albizia lebbeck)*	400-1000	12 x 12	-- 5-7 years	• May also be planted on farm bund and boundary • Leaves are edible to sheep, goat and camels
Zhar beri *(Zizyphus nummularia)*	150-400	5 x 5	3-5 kg leaves 3-4 years	• Considered as best bush for wasteland development and silvopasture, may be planted on rocky and semi-rocky habitat also • Leaves locally known as pala are edible to all animals • Fruits are relished by desert dwellers
Khara Jal *(Salvadora persica)*	400-700	15 x 15	100-120 kg leaves 8-10 years	• Suitable for saline soils • Leaves are edible to sheep, goat and camel • Fruits are delicious and consumed by desert dwellers during summer

Tree/shrub	Suitable rainfall zone (mm)	Optimum plant geometry (m)	Green fodder yield/plant and availability after plantation	Utilization aspects
Meetha Jal *(Salvadora oleoides)*	350-600	12 x 12	80-100 kg leaves 8-10 years	• Suitable for saline soils • Leaves are edible to sheep, goat and camel • Fruits are delicious and consumed by desert dwellers during summer
Gundi *(Cordia gharaf* syn. *C. rothii)*	300-500	8 x 8	5-8 kg 3-4 years	• May be planted on farm boundary • Suitable for plantation on semi-rocky areas also • Leaves are edible to sheep, goat and camel • Fruits are delicious and consumed by desert dwellers

- Appropriate depth of the pit for plantation: 60 cm x 60 cm x 60 cm,
- Appropriate time for digging of pit: May-June
- Suitable time of establishment of nursery for raising seedlings: February-March
- Suitable time of plantation of seedlings: July-August after effective rainfall.

Drought and famine are common features of arid zone, which adversely affect productivity and survival of animals. Therefore, conservation of surplus quality fodder for famine and lean period is an extremely important aspect for sustainable livestock production. Some suggestions for fodder conservation and utilization are as under (Anonymous, 2012):

i. Feed and fodder bank may be established at village *Panchayat* level. Financial assistance for construction of fodder storage structure, bailing, transportation, etc. may be provided by the Government.

ii. About 30% fodder may be saved merely by feeding chaffed fodder in a manger. Therefore, installation of chaff cutter and construction of manger in each and every family must be ensured for stall-fed animals.

iii. Surplus green fodder of cereals may be preserved by silage for maintaining health and productivity of animals during lean period. Additives like 1.0-1.50% urea, 8-10% molasses and 6-8% butter milk helps in enhancing palatability, digestibility and nutritive value of silage. This technology needs to be demonstrated and popularized in general, and for commercial dairy farms in particular.

iv. The palatability, digestibility and nutritive value of dry straw and stover may be enhanced by mixed feeding of dry and green fodder, soaking of dry fodder in water and mixing with concentrate just prior to feeding.

v. Production of multi nutrient feed block [including wheat straw (40%), molasses (20%) dry leaves of berseem/lucerne (20%), concentrate mixture (19%) and mineral mixture and vitamin additives (1%)] need to be augmented and its utilization for animals should be promoted particularly during lean period. Use of mineral mixture needs to be popularized for health and productivity of animals.

vi. Relief department should also make sincere efforts to encourage fodder storage rather than spending money on importing fodder from a long distance during famine.

Conclusion

The availability of nutritious fodder is essential for sustainable animal production. Therefore, there is high need to augment high quality fodder production adopting significant varieties and improved crop management practices of cultivated fodders including dual purpose crops, pasture improvement adopting technological interventions and plantation of woody perennials to establish live fodder bank. Drought and famine are common features of arid zone, which adversely affect production and survival of animals. Therefore, conservation of surplus quality fodder for famine and lean period is an extremely important aspect for sustainable livestock production.

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