IMPROVING LIVELIHOOD OF FARMERS THROUGH LIVESTOCK INTERVENTIONS IN NAGAUR DISTRICT OF RAJASTHAN

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ICAR

Central Arid Zone Research Institute

ISO 9001 : 2008

(Indian Council of Agricultural Research)

Jodhpur - 342 003 (Rajasthan)

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Published by:

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Central Arid Zone Research Institute
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Fax: +91 291 2788706
Web site: www.cazri.res.in

Correct citation: Patidar, M., Patel, A.K., Misra, A.K., Sirohi, A.S., Kumawat, R.N., Meghwal, P.R. and Roy, M.M. 2014. Improving Livelihood of Farmers through Livestock Interventions in Nagaur District of Rajasthan. Central Arid Zone Research Institute, Jodhpur, 56 p.

October, 2014

DTP : S.B. Sharma

Printed at: Evergreen Printers, Jodhpur, Tel. : 0291-2747767

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Foreword

The arid and semi-arid regions of the states of Rajasthan and Gujarat in India are characterized by low and erratic rainfall, low levels of economic activity, high incidence of land degradation and a high concentration of rural poor. Livestock in these regions helps in moderating risks, provide resilience, diversify livelihood and can be migrated or liquidated during calamities. The crop and livestock production are complimentary to each other in minimizing risks and enhancing sustainability in the region. More than 51% of the livestock in the state of Rajasthan (83.3% camel, 75% sheep, 54.4% goats, 41.3% cattle and 31.1% buffaloes) are concentrated in the arid region and are the major source of livelihood of resource poor farmers. However, the livestock production in these areas are characterized by low productivity, low fertility, shortage of feed resources and low uptake of technologies by the farmers.

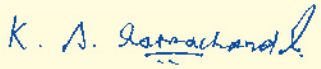
The Government of India has recognized the livestock development as an important tool for poverty alleviation. However, most of the approaches/area development schemes consider the livestock component as an end intervention.In arid eco-regions where livestock assumes significant role in contributing to the overall household incomes, a paradigm shift is needed in the approach for promoting livestock production systems by considering livestock as a central intervention and build other enabling conditions around this activity.

Addressing the importance of livestock wealth and feed and fodder scarcity in the arid regions, National Rain-fed Area Authority (NRAA) has granted

a pilot study project on livestock centric intervention for livelihood improvement in Nagaur district of Rajasthan. The Pilot study is being implemented in a consortia mode by Central Arid Zone Research Institute (CAZRI), Jodhpur in partnership with Rajasthan Livestock Development Board (RLDB) & leading NGO i.e. Gramin Vikas Trust (GVT). A cluster approach with effective integration of other natural resource components has been adopted in the pilot study. The institute has developed formulations and appropriate technologies for production of various feed products viz. multi-nutrient feed block and multi-nutrient feed mixture for supplementing nutrients to livestock to maintain their health and productivity under different feed and fodder scarcity conditions. The technologies developed and demonstrated by the institute have been well accepted by the farmers in the project area and benefited the livestock owners. The institute has also demonstrated agronomic practices for round the year forage production and pasture development, involving annual and perennial grasses.

This publication aims to compile the information generated from the study. It provides useful information on livestock management and fodder production strategies demonstrated at field level in the project area.

I compliment the research team and editors for producing this bulletin on time. I am sure that this bulletin would be very useful to the researchers, extension workers, NGO's and entrepreneurs engaged in livestock farming sector.



(K.S. Ramachandra)

13th October, 2014

Preface

India has 31.7 m ha (11% of geographical area) of hot arid land, of which 62% is in the western part of Rajasthan state. In this state, these dry areas are supporting high population of 107 human and 137 animals per square km. The arid and semi-arid regions of the states of the Rajasthan and Gujarat in India are characterized by low rainfall, low levels of economic activity, high incidence of land degradation, and a high concentration of rural poor. Low public and private sector investment especially in agriculture research and technology, low adoption rates of improved technologies, inadequate market linkages are some of the reasons for slower development of agriculture and allied sectors in the region. This, coupled with increased incidences of drought, has led to the poorer sectors of rural societies, the small producers, becoming even more marginalized. Livestock in these regions helps in moderating risks, provide resilience, diversifying livelihood and can be migrated or liquidated during calamities. However Livestock production systems in these areas are characterized by low productivity, low fertility, shortage of feed resources – especially green forage. Resource poor farmers depend heavily on livestock as a major source of income. A Pilot study on livestock centric interventions for livelihood improvement in Nagaur district of Rajasthan has been conducted by Central Arid Zone Research Institute (CAZRI), Rajasthan Livestock Development Board (RLDB) & Gramin Vikas Trust (GVT) in consortia mode and funded the National Rainfed Area Authority, Govt. of India. The study focused on the interventions which helped to increase feed and forage resources and strengthening livestock production and thus improving the livelihood of the farmers in the region. The results of various activities undertaken by CAZRI, Jodhpur at farmers' field in twelve villages of Nagaur district are compiled in the form of technical bulletin. The present bulletin on Improving Livelihood of Farmers through Livestock Interventions is the need of hour and will be useful for researchers, and policy planners for promoting livestock production in the system approach. The refined technological model can be replicated in similar agro-ecological conditions in India and elsewhere.

The authors acknowledge their deep sense of gratitude to Dr. K.S. Rama Chandra, Technical Expert (AH & F) NRAA, New Delhi for guidance and financial support for implemention of project. We are thankful to Dr. N.V. Patil, Director, NRC Camel, Bikaner who took keen interest in initiation of the project at farmers field. Grateful thanks are due to Dr. H.C. Bohra, Dr. B.K. Mathur, Dr. T.K. Bhati and Dr. Nisha Patel for suggestions and guidance in project activities. The authors also acknowledge the contributions made by officials of GVT and RLDB. The help rendered by Shri Vinod Kumar Kudi SRF and Mukesh Bairwa was also acknowledged. Thanks are also due to selected farmers of different adopted villages of Nagaur district for their cooperation in conducting field trials on their farm, the present bulletin has emerged from these trials.

Authors

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List of abbreviations

CAZRI	:	Central Arid Zone Research Institute
CFB	:	Complete Fodder Block
DFY	:	Dry Fodder Yield
EC	:	Electrical Conductivity
GDP	:	Gross Domestic Product
GFY	:	Green Fodder Yield
GVT	:	Gramin Vikas Trust
IFS	:	Integrated Farming System
MNB	:	Multi-Nutrient-Block
MNM	:	Multi-Nutrient-Mixture
NCAER	:	National Council for Applied Economic Research
NDDB	:	National Dairy Development Board
NGO	:	Non-Governmental Organization
NRAA	:	National Rainfed Area Authority
OBC	:	Other Backward Caste
OC	:	Organic Carbon
PRA	:	Participatory Rural Appraisal
RLDB	:	Rajasthan Livestock Development Board
RRA	:	Rapid Rural Appraisal
SC	:	Scheduled Caste

INTRODUCTION

Livestock rearing is an integral component of economic and social fabric of the rural masses in Rajasthan. Since crop farming is constrained by erratic rains and limited irrigation facilities, livestock is an adjunct farm enterprise in most parts of the state especially in arid areas, which covers nearly 60% of total geographical area of the state (34.23 m ha). This region is characterized by scanty and erratic annual precipitation (100-420 mm), high evapo-transpiration (1500-2000 mm), high temperatures and poor fertility of the soil resulting in low biomass producing conditions. In addition to frequent droughts, extreme events triggered by climatic change may pose serious threat to survival of living beings in arid region. However, land resources and demographic structure make animal husbandry dominant in the agriculture system of the arid region. Animal husbandry plays an important role in livelihood security and economic sustenance of rural people by providing regular employment and income generation throughout the year and also provide security against the risk in agriculture. A study by National Council of Applied Economic Research observed that revenue from milk sale accounted for 22% of the family income in the state and Rajasthan contributed 10% of the total milk production in the country (NCAER, 1990). The livestock sector is more labour intensive than crop production and accounts for a major share in rural employment with 4.5% annual growth as compared to 1.75% for all sectors and 1.1% for agriculture (Bohra *et al*., 2012). Accordingly to Rajasthan livestock policy documents 9.16% of the GDP of the state is contributed by animal husbandry sector (Anonymous 2011) about 35% of income of small and marginal farmers comes from dairy and animal husbandry, but in arid areas its contribution is as high as 50%. The importance of the livestock sector, especially in the arid areas, can easily be appreciated from the data on annual employment generation provided by Kalla and Goyal (1986) who estimated that cropping activities provided only 16 standard days/year/household while livestock rearing accounted for nearly 300 standard days/year/household.

Livestock population and production in arid zone

Rajasthan is the largest state of India endowed with huge livestock production which is at present 56.66 million (Livestock Census 2007) and arid Rajasthan harbours 29.11 million of animal heads comprising 17.35% cattle, 11.85% buffaloes, 28.96% sheep, 40.19% goats and 1.2% camels and remaining mainly equines. The livestock population has increased by 61% during last century. The growth rate of sheep, goat and buffaloes is higher as compared to cattle. The Man to Livestock ratio is much higher in arid areas.

There are 107 heads of livestock per 100 persons in arid zone as against 66 in Rajasthan state and 83 in whole country. The land availability per unit of livestock is more in arid region but fodder resources are much less than rest of the state. Livestock in arid region contributes significant share of production in terms of milk (41.77%), wool (76.01%) and meat (53.44%) in the total production of the state (Patil *et al*., 2009). The per capita availability of milk in Rajasthan is 539 against 290 g/day in the country (NDDB, 2012). Despite the significant contribution of arid livestock to the production in the state, there is concern about the productivity of animals in the region, the average milk yield per head of cow, buffalo and goat was 4.13, 5.60 and 0.87 kg per day (Patil *et al*., 2009). The average productivity of livestock is lower than the irrigated areas. It is primarily due to shortage of good quality of fodder and other critical nutrients which are required for maintenance of normal physiological functions, production and reproduction of animals.

Forage scenario of arid Rajasthan

Grazing of livestock is a common practice in arid zone of Rajasthan as about 50% of total area of western Rajasthan is available for gazing mainly for cows, sheep and goat, however, the availability of green fodder is restricted to monsoon and post monsoon months only and during rest of the period livestock graze on dry grasses and crop residues available in cultivated, fallow and wastelands and other grazing lands. The availability of fodder in western Rajasthan from different sources is presented in Table 1. Its availability is not only less but the quality of fodder is also very poor. The production from the available grazing lands is hardly 300-400 kg /ha. This low productivity is due to deterioration and over grazing. Further, the occurrence of droughts are common in arid regions which affects agricultural and forage production. This coupled with degraded grazing lands caused feed and fodder deficit for large population of livestock in arid zone. Estimates worked out on the requirement of feeds and fodders in arid zone vary widely. The fodder deficit of western Rajasthan is estimated to be as high as 60 per cent of the demand and ranges from 55 per cent in western districts to 69 per cent in central districts and 72 per cent in eastern districts (Pratap Narain and Kar, 2005). This situation is further aggravated during drought years. The deficiency of dry and green fodder was estimated to 35.9 per cent and 79.9 per cent during drought year (Patidar and Saxena, 2007). The requirement and availability of fodder during different situations is described in Table 2. The acute fodder shortage in central and eastern districts is due to 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. To address this issue, there has been a general awakening at various levels

among land and livestock owners regarding the need for an application of advanced technologies to improve the deteriorated and depleted pastures, cultivation of dual purpose crops to increase grain and fodder, green fodder cultivation from limited irrigation; and use of technologies for Complete Feed Block (CFB), Multi Nutrient Block (MNB), Multi Nutrient Mixture (MNM) and urea treatment to supplement nutrients to the livestock for maintaining their health and productivity at sustained levels.

Table 1: Fodder availability from different sources in Western Rajasthan

Source of fodder	Area 000 (ha)	Fodder yield (t /ha)	Total fodder yield (mt)
Green fodder			
Grazing lands	8946	0.40	3.58
Weeds from irrigated areas	1666	1.50	2.50
Cultivated fodder	148	2.64	3.90
Other crops	-	-	0.30
Top feeds - Agroforestry	-	-	2.50
Total green fodder			12.78
Dry fodder			
Dry fodder (crop residues and stubbles)	10920	1.10	12.092
Grasses and other top feeds/crops	-	-	1.908
Total dry fodder			**14.00**

(Source: Patidar 2012)

Table 2: Requirement and availability fodder in arid zone Rajasthan

Fodder	Requirement (mt)	Availability (mt)		Deficit (%)	
		During normal year	During drought year	During normal year	During drought year
Dry fodder	22	14.00	7.68	36	65
Green fodder	41	12.78	10.71	69	74
Concentrate	13	2.66	0.67	80	94

(Source: Bohra *et al*., 2012)

PROJECT DESCRIPTION

The Pilot study on livestock centric intervention for livelihood improvement in Nagaur district of Rajasthan is supported by the National Rainfed Area Authority. This project was launched in Nagaur district of Rajasthan in consortia mode involving Central Arid Zone Research Institute (CAZRI), Rajasthan Livestock Development Board (RLDB) and Gramin Vikas Trust (GVT). The project, sanctioned for a period of four years from 2010 to 2014, aims at moderation of risk, providing resilience, diversifying livelihood and dilution of calamities. The focus of the project was strengthening livestock production as central intervention and buildup of other enabling condition around this activity. Total 12 villages in four clusters of two Tehsils namely Jayal and Merta were selected for the implementation of project activities. An average of 1000 households from each cluster were considered for the study after completing the socio-economic survey. The role of CAZRI in this project was to implement evaluate the technologies for livestock and forage production i.e. enhancing the biomass production through developing silvipasture models, use of dual purpose coarse cereal varieties, and green fodder cultivation under limited irrigation for providing round the year fodder. Feed technologies related to need base supplementations as per livestock species involved use of multi-nutrient feed block, feed mixture and complete feed block. A large quantity of low grade roughage, crop residues etc. were enriched through urea treatment for providing feed to bovine to fulfill their protein requirements. The outcome of this project was evaluated on the basis of increased availability of forage and overcoming the deficiency of certain mineral nutrients to dairy animals and small ruminants. The long term objective of project was to increase the overall livestock productivity by implementing technological options for increasing forage availability and supplementary feeding strategy for scarcity period. The project had following objectives to contribute positive changes in the livelihood of the rural people:

1. To enhance the biomass production and improvement in livestock feeding
2. To introduce the dual purpose coarse cereal crops for higher forage production
3. To encourage the green fodder cultivation round the year for higher productivity, and
4. To introduce the spineless cactus cultivation as alternative livestock feed resource

Description of project site

The project was implemented in a cluster of villages in two tehsils of Nagaur district. The district is situated between 26^0 25' & 27^0 40' North Latitude and 73^0 10' & 75^0 15' East Longitude. The total area of the district is 17,718 sq. km., out of which 17,448.5 sq. km. is rural and 269.5 sq. km. is urban. There are 1607 revenue villages in the district spread over in 10 Tehsils. As per the 2011 census, Nagaur district comprised 5,78,809 households of which 4,76,736 households are in rural areas. The total population of the district is 33,07,743 (6,37,204 urban and 26,70,539 rural population) which is 4.82% of the total state population. The density of population in the district is 187, as against 200 of Rajasthan as a whole. The total livestock population of district is 31,15,488 and that of Rajasthan is 5,66,63,183 according to 2007 census. The ratio between human to livestock is 1.06 and 1.20 respectively for the district and state. In the district, livestock population constitute 13.4, 14.8, 25.5 and 45.6 per cent cattle, buffalo, sheep and goat, respectively. Nagaur has a dry climate with a hot summer. Sand storms are common in summer. The climate of the district is characterized by extreme dryness, large variations in temperature with highly variable rainfall. The maximum temperature recorded in district is 47^0 C with 0^0 C as the lowest recorded temperature with an average of 23.5^0 C. The winter season extends from mid-November to the beginning of March. Rainy season is from July to mid-September. The average rainfall in the district is 361.6 mm. Ground water is generally brackish to saline with few pockets having fresh water. The soils are sandy loam, shallow depth red soils in depressions. The nutrient status of the Nagaur soil is graded as medium to high level. The district of Nagaur is poor in forest resources, which is only 1.3 per cent of total geographical area of the district. About 25% of total area including pasture, fallow land, oran, gochar and wasteland is available for grazing of livestock and about 70 % is net cultivated area of which 24% is used for cultivating irrigated crops. Among the crops pearl millet, sorghum, cowpea, clusterbean, mung bean, moth bean and sesame are major crops, grown under rainfed condition during *kharif* season. Barley, wheat and mustard are the major crops of *rabi* season under irrigated condition. The other crops of the district are cumin, isabgol, fenugreek, taramira, rape seed and gram. In some pockets, sorghum and pearl millet are grown for fodder purposes under irrigated condition during summer, while lucerne is grown during *rabi* season.

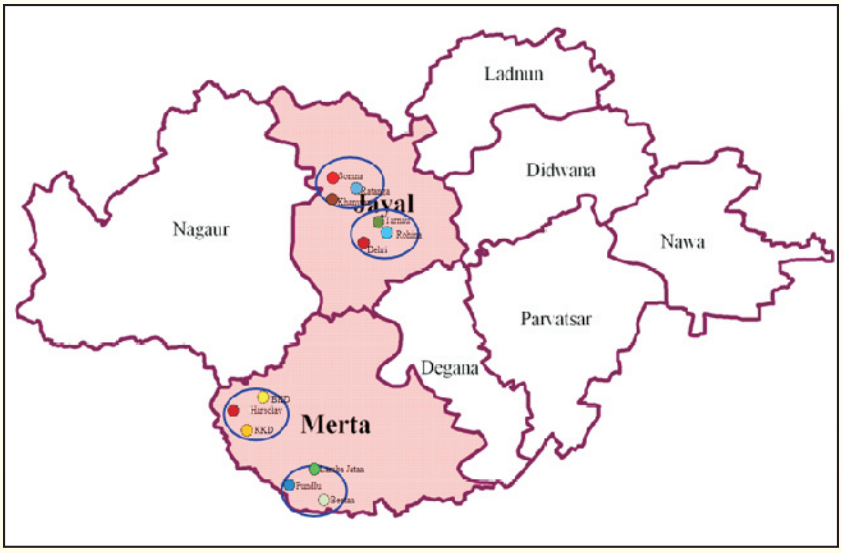


Figure 1a: Map of Nagaur districts depicting the location of operational villages

Twelve villages grouped in four clusters of two Tehsils namely Jayal and Merta were selected as given in Fig. (1). Villages in Jayal tehsil are located in north central part of Nagaur district which is comparative arid type and dry climate, soils texture vary from fine sandy loam to loam. The soils are low in nitrogen, medium in phosphorus and potash with poor water retention capacity.

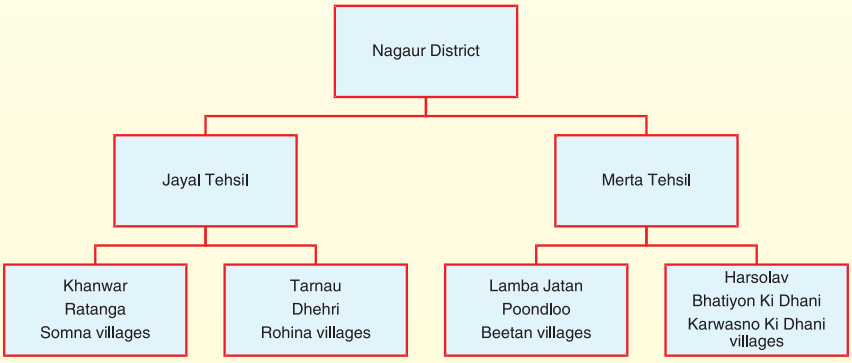


Figure 1b: Schematic representation of villages tehsil wise

28% of cultivated area is irrigated which is mainly by tubewells. About 24% area is barren and fallow, and is used for livestock grazing. Buffaloes are preferred to cows for milk purpose as indicated by the increased numbers of buffaloes, which are 47% of the bovine population. Sheep and goats are almost in equal numbers and reared by small, marginal and landless farmers.

In Merta tehsil, soils are light in texture; part of this tehsil has deep sandy loam, while red loamy soils exist elsewhere. Most of soils are poor in fertility and alkaline in reaction. However the irrigated area is comparatively more (53.8 % of cultivated area) in clusters of Merta tehsil while 22 % of total land is fallow and barren which is used for livestock. In livestock composition again buffalo population is increasing, which is about 48.4 % of bovine population.

Table 3: Salient features of Merta and Jayal tehsils

Particulars	Jayal	Merta
Location	27°22′ N 74°18′ E	26°39′ N 74°06′ E
Total geographical area (ha)	208102	229728
Human population (2011)	269024	388929
Livestock population (2003)	228779	340068
I. Cattle	34855	44671
II. Buffalo	33116	58836
III. Goat	94622	108708
IV. Sheep	60855	120411
V. Other	5331	7442
Net sown area (2006-07) (ha)	160953	174589
Irrigated area (ha)	12576	72788
Area available for grazing (ha)	46149	55139
Average rainfall (mm)	325.40	416.60

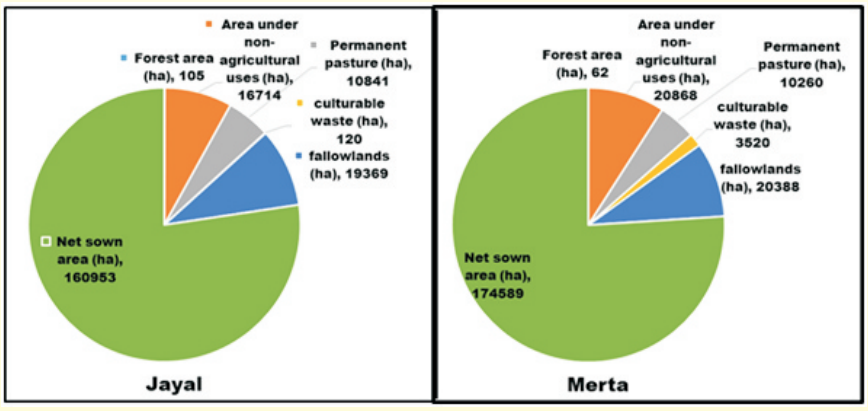


Figure 2: Land-use pattern of Jayal and Merta tehsils

Table 4: Salient features of selected villages of Jayal and Merta tehsils

Tehsil	Village	Geographical area (ha)	Cropped area (ha)	Irrigated area (ha)	Pasture land (ha)	Population**	Total house hold	Livestock population*
Jayal	Rohina	1679	1537	188	271	3350	563	2466
	Dehri	1918	1610	594	184	2544	413	1693
	Tarnau	2921	2411	658	206	5545	1050	3633
	Somna	3253	2349	488	378	4388	795	6614
	Ratanga	3229	2416	474	344	2746	470	2552
	Khanwar	1395	831	222	128	1246	191	1528
	Total	14335	11246	2631	3014	16863	3482	18486
Merta	Harsolav	5919	5112	1194	97	10607	2300	9879
	K.K.D	885	548	258	69	3181	220	3487
	B.K.D	1111	765	123	94	1948	175	1187
	Lambajatan	3528	3222	1807	105	5573	825	4675
	Pundlu	4147	2512	1806	172	6927	671	4209
	Beetan	2532	1709	561	244	3537	626	3415
	Total	18122	13868	5749	781	31773	4817	26852

*Population according to 2007 livestock census, **Human population according to Census 2011
B.K.D.: Bhation ki dhani, K.K.D.: Karvason ki dhani

Socio-economic profile of farmers in different villages of project

As per the objective of the project, the bench mark survey was conducted in collaboration with GVT, a consortium partner of the project. Selected 4000 beneficiary households from 12 villages through Participatory Rural Appraisal (PRA) and Rapid Rural Appraisal (RRA) techniques. The information of total geographical area of village, cropped area, irrigated, total human and livestock population and total number of families was collected (Table 4). The information on socio-economic characteristics was collected by filling the schedules required for providing the suitable intervention to the farmers as per their needs and to improve their earnings. Farmers were categorized into marginal, small, medium and large classes according to size of their land holdings. Similarly, information on average livestock size in each category was also collected for providing maximum benefit to farmers having livestock based farming for their livelihood (Table 5). Majority of the farmers belong to OBC community. The farmers of SC community are more in the small and marginal category while most of the farmers in

medium and large farmers' categories belong to general and OBC community, and they have more resources and income than small and marginal farmers in almost all villages. The crops grown during *kharif* are generally rainfed. Underground water is the main source of irrigation and only medium and large farmers have tubewell facilities for irrigating crops during *rabi* and cash crops during *kharif*. The distribution of livestock is strongly correlated with the category of farmers. In general medium and large farmers having assured irrigation sources reared buffaloes and cattle, while majority of small and marginal farmers have small ruminants. The rearing of goats is dominant over sheep in most of the villages, and it is common among most of the farmers. The herd size of sheep is much larger than the goat. The main source of income for large and medium farmers is from crop based enterprises while livelihood of small and marginal farmers is supported by the small ruminants.

Soil and water quality in different cluster of villages

Soil plays a major role in determining the sustainable productivity of an agro-ecosystem, as it supplies nutrients to the plants. The aim of the study was to evaluate quality parameters of soils and irrigation water at different sites and to find out their relationship with crop yield. 39 soil samples from surface soil (0-20 cm depth) and 37 water samples from tubewells were collected from experimental sites in different villages. In arid region, ground water is the major source of irrigation to supplement the scanty rainfall. But the quality of ground water is generally poor. Therefore it is necessary to suggest appropriate technologies to farmers according to quality of water at a particular site. Water samples were analyzed for pH and EC. The mean pH value in selected villages ranges from 7.76 to 8.22 and EC value from 2.76 to 7.37 dS m^{-1} indicating that the water is moderately saline (Table 6). The level of salinity is high in Khanwar and Tarnau Cluster of Jayal tehsil. The continuous use of poor quality irrigation water is deleterious to soil health and reduces crop yield. Therefore, suitable crops and varieties, use of organic manure and proper irrigation methods were suggested to farmers for getting higher yields.

The soil was analyzed for organic carbon, pH, EC, available P and K and water for pH and electrical conductivity (Table 7). The analyzed samples showed low organic carbon content, ranging from 0.02-0.39%, low to high available P (2.4-37.2 kg/ha) and medium to high available K (90-753 kg/ha). Organic carbon, available P and K content of soil of Lamba Jatan cluster is higher than Harsolov, Khanwar and Tarnau cluster. The

Table 5: Socio economic profile of twelve selected villages of Jayal and Merta Tehsils

Village	Categories	Average size of holding (ha)	Caste wise families selected				Average number of livestock per family			
			General	OBC	SC	Total	Buffaloes	Cattle	Goat	Sheep
Harsolov	Marginal	0.61	4	73	53	130	1.10	1.12	4.28	1.33
	Small	1.54	10	187	65	262	0.91	1.20	4.57	2.70
	Medium	2.91	30	152	50	232	1.90	1.43	3.90	5.91
	Large	8.42	27	142	19	188	3.13	2.24	4.32	6.13
	Total/Average	2.7	71	554	187	812	1.76	1.50	4.27	4.02
Bhatiyon Ki Dhani	Marginal	0.53	3	6	5	14	0.64	1.60	2.90	3.08
	Small	1.64	10	7	1	18	1.89	2.00	3.10	0.00
	Medium	3.05	4	7	4	15	1.00	2.30	4.60	16.00
	Large	6.92	17	18	2	37	1.92	2.10	4.40	8.24
	Total/Average	3.03	34	38	12	84	1.36	2.00	3.75	6.83
Karwasaro Ki Dhani	Marginal	0.83	1	0	0	1	1.00	0.00	10.00	10.00
	Small	1.67	1	6	0	7	2.28	1.14	8.57	3.80
	Medium	3.17	5	19	2	26	2.81	1.42	2.88	3.84
	Large	6.83	0	70	0	70	4.03	1.93	1.34	4.87
	Total/Average	3.13	7	95	2	104	2.53	1.12	5.70	5.63
Beetan	Marginal	0.71	0	3	12	15	0.20	0.20	2.20	0.00
	Small	1.58	2	19	51	72	0.04	2.24	3.53	1.81
	Medium	2.89	25	62	33	120	0.96	0.62	2.54	1.50
	Large	6.50	11	57	8	76	2.11	0.64	2.79	3.42
	Total/Average	2.92	38	141	104	283	0.83	0.93	2.77	1.68
Pundlu	Marginal	0.72	2	15	34	51	0.81	0.61	5.68	9.33
	Small	1.63	11	42	38	91	1.61	0.74	3.48	3.85
	Medium	2.93	3	51	39	93	1.91	0.78	3.52	2.75
	Large	6.06	4	126	19	149	3.39	1.17	2.40	2.10
	Total/Average	2.83	20	234	130	384	1.93	0.83	3.77	4.51
Lamba Jatan	Marginal	0.71	3	10	25	38	0.51	0.13	3.00	1.57
	Small	1.70	3	19	27	49	0.54	0.40	2.79	1.67
	Medium	2.87	15	22	32	69	1.05	1.44	2.45	0.00
	Large	7.14	24	147	6	177	2.53	0.61	6.28	0.45
	Total/Average	3.10	45	198	90	333	1.16	0.65	3.63	0.92

Village	Categories	Average size of holding (ha)	Caste wise families selected				Average number of livestock per family			
			General	OBC	SC	Total	Buffaloes	Cattle	Goat	Sheep
Rohina	Marginal	0.63	10	16	32	58	0.65	0.22	1.90	0.00
	Small	1.63	38	26	24	88	0.91	0.71	1.70	0.00
	Medium	2.83	39	24	10	73	1.95	0.73	2.70	0.14
	Large	7.17	35	23	1	59	2.14	0.75	2.60	0.41
	Total/Average	3.07	122	89	67	278	1.41	0.60	2.23	0.14
Dehri	Marginal	0.57	0	22	26	48	0.33	0.20	2.52	0.00
	Small	1.59	0	22	16	38	1.68	0.26	0.26	0.26
	Medium	2.98	3	43	6	52	1.30	1.27	0.87	1.97
	Large	7.67	1	64	1	66	2.45	0.30	0.73	1.97
	Total/Average	3.20	4	151	49	204	1.44	0.51	1.10	1.05
Tarnau	Marginal	0.56	11	50	33	94	0.10	0.32	1.40	0.00
	Small	1.54	11	59	33	103	0.50	0.38	1.38	0.00
	Medium	2.95	9	93	34	136	0.90	0.65	1.23	1.90
	Large	7.17	4	168	13	185	1.50	0.71	0.85	1.98
	Total/Average	3.06	35	370	113	518	0.75	0.52	1.22	0.97
Khawar	Marginal	0.63	0	4	6	10	0.00	0.43	3.14	0.00
	Small	1.63	3	18	19	40	1.21	1.03	4.10	0.00
	Medium	2.89	7	20	6	33	1.62	0.71	4.10	0.00
	Large	7.40	15	19	15	49	2.05	1.00	4.22	8.41
	Total/Average	3.14	25	61	46	132	1.22	0.79	3.89	2.10
Ratanga	Marginal	0.70	3	11	15	29	0.38	0.41	3.41	0.52
	Small	1.71	7	37	17	61	0.49	0.66	3.15	0.26
	Medium	2.84	11	54	47	112	0.79	0.85	2.13	0.77
	large	7.63	15	101	4	120	2.36	0.88	2.13	2.50
	Total/Average	3.22	36	203	83	322	1.01	0.70	2.71	1.01
Somna	Marginal	0.71	6	71	54	131	0.20	0.19	3.30	4.19
	Small	1.61	5	85	40	130	0.43	0.83	3.17	8.77
	Medium	2.91	8	72	44	124	0.83	0.95	2.65	2.34
	Large	6.28	15	136	10	161	2.10	0.92	1.70	0.69
	Total/Average	2.88	34	364	148	546	0.89	0.72	2.71	4.00

Table 6: Quality parameters of water in different clusters of villages in Nagaur District

Cluster	No. of samples	pH		EC (dS m^{-1})	
		Range	Mean	Range	Mean
Lamba Jatan	12	7.77-8.77	8.22	1.42-8.02	4.57
Harsolav	11	7.66-8.72	8.22	1.75-5.17	2.76
Khanwar	7	7.62-8.45	8.10	3.96-8.69	6.60
Tarnau	7	7.5-8.17	7.76	5.05-10.27	7.37

mean pH (7.5-8.39) and EC (0.37-2.25 dS m^{-1}) values indicated that soils were moderately alkaline in nature. The EC value of soil in Lamba Jatan and Tarnau cluster was higher than Harsolov and Khanwar.

Table 7: Physico-chemical properties of soil in different clusters of villages in Nagaur District

Cluster	No. of samples	pH		EC (dS m^{-1})		OC%	
		Range	Mean	Range	Mean	Range	Mean
Lamba Jatan	6	7.1-8.4	7.5	0.23-10.9	2.25	0.15-0.37	0.29
Harsolav	8	8.1-8.9	8.39	0.09-1.42	0.37	0.02-0.27	0.18
Khanwar	18	7.2-9.0	8.16	0.08-2.1	0.58	0.02-0.39	0.18
Tarnau	7	8-8.4	8.25	0.11-4.2	2.17	0.14-0.25	0.18
Available P (kg/ha)					Available K (kg/ha)		
Cluster	Sample	Range		Mean	Range		Mean
Lamba Jatan	6	11.9-32.5		23.72	151-393		279.83
Harsolav	8	11.2-37.2		19.81	101-753		228.13
Khanwar	18	7.2-32.8		18.96	146-410		247.11
Tarnau	7	2.4-17.8		14.5	90-196		216.34

Project partners

The project was implemented and managed in a partnership mode between Central Arid Zone Research Institute, Jodhpur with Rajasthan Livestock Development Board, Jaipur, Government of Rajasthan and NGO, Gramin Vikas Trust. Multi-disciplinary team of scientists and experts was constituted from each institution keeping in view the objectives and responsibilities of individual institutions. CAZRI was assigned

responsibility of providing necessary technical support in various activities, evolving and implementing suitable crop pattern in the area and undertaking promotion and propagation of forage production technologies including dual purpose fodder crops. The activities of the RLDP were primarily focused on livestock health care, breeding aspects, convergence of various schemes, and also providing logistic support in the study area. The community mobilization and socio-economic studies were carried by NGO.

PROJECT METHODOLOGY

The 12 villages were grouped in four clusters having similar type of micro-climatic situations. Before undertaking various activities or interventions at farmers' field, baseline survey was conducted through Participatory Rural Appraisal (PRA) and group discussion with the farmers for assessing the existing farming system, natural resource availability and common property resources. Farmers were selected for adoption of technology packages as per their need and suitability, socio-economic concern and demographic profile through group discussions. The plan of action for different interventions were:

1. Three to five farmers for each crop intervention were selected from adopted villages.
2. On-farm trials of *kharif*, *rabi* and summer season crops were undertaken at 0.25 ha area on each field with improved cultivation practices.
3. Improved fodder grasses such as *Cenchrus ciliaris* and *C. setigerus* were grown in association with fodder trees on farmers' field and on common pasture land at 2 to 3 locations in each Tehsil.
4. Spineless Cactus cladodes (*Opuntia ficus-indica*) were planted on the bunds and field boundaries at 2 to 3 locations.
5. On-farm trials of Multi-Nutrient Blocks were carried out in bovine at 5 to 10 households in each village.
6. On-farm trials of Multi-Nutrient Mixtures were also undertaken in small ruminants at 5 to 10 households in each village.
7. Enrichment of low grade roughage and Complete Fodder Blocks were introduced in the existing deficient feeding system of cattle and buffaloes.
8. Complete Fodder Block making unit was installed at Gaushala of Harsolav village under participatory mode of management.

9. On- and off-campus farmers' trainings were organized on various aspects for capacity building of farmers and faster diffusion of technologies.

CAZRI activities undertaken under the project

The Central Arid Zone Research Institute is a national research institute under the jurisdiction of Indian Council of Agricultural Research, mandated for improving productivity and sustainability of livestock based farming systems in Integrated Farming System (IFS) mode of rainfed and dry areas of the country. The team of CAZRI scientists comprising Livestock Production & Management, Animal Nutrition, Agronomy, Horticulture and other experts were given responsibilities for the implementation of suitable interventions on the project site. The following activities were undertaken for livelihood improvement of the farmers.

1. **Establishment of pasture and silvipasture:** The suitable perennial grasses of the region such as *C. ciliaris* and *C. setigerus* were taken for the development of pasture on common property resources, farm bunds and at farmers' fields. For establishment of silvi-pasture, suitable top feed trees: *Ziziphus nummularia*, *Z. mauritiana*, *Colophospermum mopane* and *Hardwickia binata* were planted in between rows of perennial grasses for supply of green fodder to the livestock during dry season.
2. **Promotion of dual-purpose fodder crops:** Improved dual-purpose varieties of pearl millet and sorghum were promoted for getting better fodder yields in addition to grain on the farmers' field. The surplus fodder was stored in the fodder bank so that in the situations of feed scarcity or the lean season the coarse roughage could be utilized for feeding the livestock.
3. **Year-round-forage-production:** For year-round-fodder-production the cropping calendar was planned and long duration fodder crops such as pearl millet, sorghum and clusterbean during summer, and lucerne, barley and oat during *rabi* season were cultivated on the farmers' fields to provide green fodder to the livestock throughout the year.
4. **Cultivation and use of cactus for animal feeding:** Planting of thornless cactus was promoted on wastelands and field bunds/boundaries to provide green fodder to the livestock with an aim to integrate the cactus with other local conventional and unconventional feeds.

5. **Enrichment of low grade roughages:** The low grade roughages like cereals straws and stover are important roughage source for arid livestock, and these can be enriched with urea to improve crude protein value. The treated straw was utilized in the feeding systems of livestock to achieve nutritionally balanced feed.

6. **Formulation and use of supplementary feeds:** The prevalent system of feeding livestock was mainly extensive type utilizing grazing resources combined with feeding on low grade roughages and very little or no supplementation is practiced even for the productive livestock. The supplementary feeds such as MNB and MNM were provided to the bovines and small ruminants in the project for improving productivity and health. The area specific formulations for such supplementary feeds using local conventional and unconventional feed resources developed at CAZRI were used for feeding the livestock economically.

7. **Formulation and feeding of complete feeds:** The arid livestock suffers from feed scarcity in most parts of the year which affects the productivity and health. In order to address the issue of feed availability during lean season, the complete feed blocks were prepared using urea, molasses, mineral mixture, wheat bran, clusterbean korma and dolomite. The feed blocks were prepared in a machine installed at the Gaushala in Harsolav village.

PROJECT ACHIEVEMENTS

1. Pasture development

Grazing lands such as permanent pastures, culturable waste, fallow land, gochar, oran etc., which occupy about 50 per cent of land, play important role in providing fodder to livestock in the arid region, even though , their productivity is very low. 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*. 2003). The production from the available grazing lands is hardly 300-400 kg/ha (Pratap Narain and Rajora 2005). The low productivity is attributed to mismanagement, degradation and over grazing of pasture land coupled with low rainfall. The productivity of these lands can be enhanced by growing drought hardy nutritive pasture grasses viz., *Cenchrus ciliaris* and *C. setigerus.* These grasses perform well on degraded lands and help in soil conservation and also

provide nutritive fodder to livestock. Keeping this in view, participatory on-farm trials were undertaken at farmers' fields to assess the performance and production potential of pasture grasses under different farm conditions and to demonstrate improved technology of pasture development for increasing the quality and quantity of fodder to sustain livestock in the region. Range grasses i.e. *C. ciliaris* and *C. setigerus* were sown in third week of July 2011 on protected common land having gravelly type of soil with poor soil fertility, on bunds and field strips and on boundaries of arable land of Harsolov and Dehri villages of Merta and Jayal tehsils respectively (Plate 1).

During the study period, seeds of *C. ciliaris* and *C. setigerus* were provided to 75 farmers covering 37 ha for establishment of pasture. Results indicated that growth attributes i.e. plant height and tillers were significantly higher with both the grasses grown on the strip of field boundary as compared to that of common land and farm bunds. Similarly forage yields also varied significantly under different situations. Maximum forage yields were with *C. ciliaris* (122.17 q/ha GFY and 28.16 q/ha DFY) and *C. setigerus* (120.0 q/ha GFY and 28.21 q/ha DFY) grasses grown on the strip of field boundary which were significantly higher than yields of grasses grown on common land and farm bunds (Table 8). The differences in growth parameters of *C. ciliaris* and *C. setigerus* were significant. Mean plant height was more in *C. ciliaris* and number of tillers per meter row length were more in *C. setigerus* but forage yields of both the grasses were at par. This shows that both the grasses are suitable for improving grazing lands of this area.

Table 8: Growth and forage yield of pasture grasses under different situation at farmer's field

Pasture Grasses	Site	Area (ha)	Plant height (cm)	Tillers/meter row length	Fresh yield (q/ha)	Dry matter yield (q/ha)
C. ciliaris	Gaushala	1.0	91.70	105.00	110.97	25.76
	Bund	2.5	79.20	70.00	105.90	25.11
	Boundary	2.0	95.80	112.00	122.17	28.16
	Total/Mean	5.5	88.90	96.00	114.00	26.36
C. setigerus	Gaushala	1.0	77.50	135.00	110.23	25.79
	Bund	2.5	69.20	96.00	107.10	24.77
	Boundary	2.0	105.00	136.00	120.00	28.21
	Mean	5.5	83.90	123.00	112.56	26.28

2. Development of silvi-pastoral system

Livestock based farming system makes significant contribution for livelihood security of farmers in arid zones of India. However, availability of fodder for livestock is not sufficient due to water scarcity and land degradation leading to low productivity of grazing lands. The arid zones are less suitable for crop production due to inherent soil constraints like low water retentivity, sandy texture, shallow depth, occurrence of rocks and stones. However, some grasses and tree species of forage value and economic importance can grow well and help in augmenting forage production. Silvipasture offers a sustainable land use system which increases overall productivity of land and make efficient utilization of natural resources.

At field bunds

At field boundary

Pasture of *Cenchrus ciliaris*

Pasture of *Cenchrus setigerus*

Plate 1: Pasture development of *C. ciliaris and C. setigerus* at different land types

Cenchrus ciliaris and C. setigerus were sown in between the trees for the establishment of silvipasture in the project area (Plate 2). During the study period, 530 ber and 371 top feed trees (khejri, *Hardwickia*, ardu and mopane) were used for the establishment of silvi-pastoral system at farmers' field to provide fodder, fruits and fuel. Besides, intervention was also undertaken on 6 ha common grazing land of Gaushala at village Harsolav in collaboration with Gramin Vikas Trust. Tree saplings of *Z. nummularia*, *Acacia tortilis, Azadirachta indica* and *Prosopis cineraria* were planted at 5 m x 4 m, 6 m x 6 m, 8 m x 5 m, 3 m x 4 m, spacing respectively and grasses were sown in inter-spaces between tree rows and in pasture land without trees. The maximum plant height (165 cm) and survival (87%) were recorded in *A. tortilis* while minimum plant height (49 cm) and survival (40%) for *Prosopis cineraria*. At initial stages tree growth and yield of grasses did not vary with tree species. Dry forage yield of grasses in silvipasture (1.41 t/ha) was higher compared to natural grasses (0.65 t/ha) but less than pure pasture of *C. ciliaris* (2.12 t/ha) and *C. setigerus* (1.98 t/ha) (Table 9). The differences in forage yield of *C. ciliaris* and *C. setigerus* was non-significant.

Table 9: Forage Yield of Grasses under Silvipastoral system on Common land of Gaushala at village Harsolav

S.No	Grass	Area (ha)	Fresh yield (kg/m^2)	Dry matter yield (kg/m^2)	Fresh yield (q/ha)	Dry matter yield (q/ha)
Pure pasture						
1	*C. ciliaris*	1.0	1.10	0.214	110	21.4
2	*C. setigerus*	1.0	0.982	0.198	98.2	19.8
Total/mean		2.0	1.041	0.206	104.1	20.6
Silvipasture						
1	Ber+ Grass	0.25	0.776	0.156	77.6	15.6
2	Khejri+ Grass	0.25	0.614	0.131	61.4	13.1
3	Babul+ Grass	1.0	0.638	0.134	63.8	13.4
4	Neem + Grass	0.5	0.686	0.143	68.6	14.3
Total/Mean		2.0	0.679	0.141	67.9	14.1
Natural pasture						
1	Natural grasses	2.0	0.26	0.065	26.0	6.5

Silvipasture

Plate 2: Silvi Pasture development

3. Fodder crops during *kharif* season

3.1. Cultivation of dual-purpose pearl millet, sorghum and clusterbean

Dual-purpose crops like pearl millet, sorghum, barley and some cultivated legumes contribute about 60-70% in the total fodder availability in arid regions. During *kharif* season, on-farm trials of improved varieties of dual-purpose crops: sorghum, pearl millet and clusterbean were conducted. Seeds of improved varieties i.e. pearl millet Raj-171, HHB-67, CZP-9802, HC-10, HC-20 (Plate 3), sorghum CSV-15, CSV-20, CSV-17 (Plate 4) and clusterbean RGC-936, 1002 and 1003 (Plate 5) were distributed to farmers for demonstrations. These improved varieties of dual-purpose crops performed better and produced higher grain and stover yields as compared to local variety (Fig 3). The improved package of practices for cultivation of pearl millet, sorghum and clusterbean

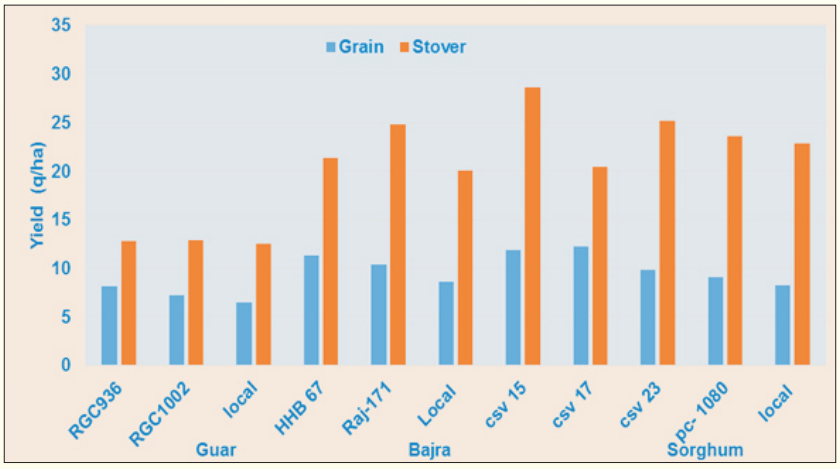


Figure 3: Grain and stover yield of different varieties of dual purpose crops in 12 selected village of Nagaur district

HC-20

HC-10

Raj 171

HHB 67 (Imp)

Plate 3: Cultivation of improved varieties of dual-purpose pearl millet during *kharif* season

CSV- 15

CSV- 24 SS

CSV- 17

CSV- 20

Plate 4 Cultivation of dual- purpose sorghum

RGC- 936

RGC- 1002

Plate 5 : Demonstration of clusterbean during *kharif* season

were demonstrated at farmers' fields. The number of on-farm trials were 264, 249 and 144 in pearl millet, sorghum and clusterbean, respectively in about 164 ha area of 12 village of Jayal and Merta tehsils. Grain yield of sorghum with improved practices varied from 9.01-24.04 q/ha with an average of 13.58 q/ha and stover yield varied from 24.95 to 58.17 q/ha with an average of 34.81 q/ha in different village of Jayal and Merta Tehsils. The mean yield of sorghum was more or less similar in both the tehsils but the increase in dry matter yield with improved practices over farmers' practices was higher with less variation in the different villages of Jayal Tehsil compared to that of in Merta Tehsil. The mean increase in grain and stover production was 25.38% and 15.93%, respectively (Table 11). Grain yield of pearl millet with improved practices varied from 9.32 to 13.35 q/ha with an average of 11.66 q/ha and stover yield varied from 20.33 to 38.36 q/ha with an average of 30.11 q/ha in different village of Jayal and Marta tehsils of Nagaur district (Table 10). The mean increase in dry matter production was 21.0% in Jayal and 14.32% in Merta. Grain yield of clusterbean with improved practices varied from 4.27 to 8.78 q/ha with an average of 6.40 q/ha and stover yield varied from 6.30 to 15.97 q/ha with an average of 10.32 q/ha in different villages of Jayal and Merta tehsils. The increase in seed yield due to improved practices over local variety was 21.20% and stover yield 3.05% (Table 12**)**. The economic returns were higher in clusterbean due to high prices of seed.

Table 10: Grain and fodder yield of pearl millet during *kharif* 2011 to 2013

Name village	No. of Trials	Yield with improved practices (q/ha)		Yield with farmers' practices (q/ha)		% increase over farmers' practices	
		Grain	Stover	Grain	Stover	Grain	Stover
Beetan	21	9.32	20.33	7.70	18.00	21.00	12.96
Bhatiyon Ki Dhani	23	12.81	37.40	11.03	32.73	16.09	14.27
Dehri	27	13.25	35.68	11.17	29.93	18.70	19.19
Harsolov	38	13.35	36.79	11.37	32.00	17.46	14.96
Karwasaro Ki Dhani	15	12.12	31.63	10.20	28.80	18.85	9.84
Khanwar	17	11.18	26.61	9.60	22.10	16.44	20.40
Lamba Jatan	14	10.95	27.91	8.50	25.15	28.85	10.95
Pundlu	22	13.21	38.36	11.23	33.63	17.63	14.04
Ratanga	28	9.83	23.14	7.25	19.60	35.57	18.07
Rohina	16	10.73	23.60	8.38	22.10	28.06	6.79
Somna	16	10.72	26.28	8.70	22.73	23.22	15.59
Tarnau	27	12.44	33.64	10.50	29.30	18.46	14.80
Total/average	264	11.66	30.11	9.64	26.34	21.00	14.32

Table 11: Grain and fodder yield of sorghum during *kharif* 2011 to 2013

Village	No. of trials	Yield with improved practices (q/ha)		Yield with farmers' practices (q/ha)		% increase over farmers' practices	
		Grain	Stover	Grain	Stover	Grain	Stover
Beetan	23	14.497	32.740	11.133	29.233	30.21	12.00
Bhatiyon Ki Dhani	24	9.210	24.950	7.050	21.950	30.64	13.67
Dehri	26	17.522	43.555	13.867	37.600	26.36	15.84
Harsolov	43	14.752	35.203	12.000	31.200	22.93	12.83
Karwasaro Ki Dhani	12	10.524	28.551	7.800	25.050	34.93	13.98
Khanwar	18	10.658	32.463	8.900	29.300	19.75	10.79
Lamba Jatan	12	12.438	34.695	9.250	26.900	34.46	28.98
Pundlu	9	24.043	58.168	20.350	51.150	18.14	13.72
Ratanga	13	9.843	25.348	7.500	23.100	31.23	9.73
Rohina	27	10.643	29.943	8.625	25.250	23.39	18.58
Somna	20	13.023	33.823	11.067	28.133	17.68	20.23
Tarnau	22	15.777	38.313	12.400	31.467	27.23	21.76
Total/average	249	13.577	34.813	10.828	30.028	25.38	15.93

Table 12: Grain and fodder yield of clusterbean during *kharif* 2011 to 2013

Name village	No. of trials	Yield with improved practices (q/ha)		Yield with farmers' practices (q/ha)		% increase over farmers' practices	
		Grain	Stover	Grain	Stover	Grain	Stover
Beetan	11	7.71	14.83	6.40	14.45	20.47	2.63
Bhatiyon Ki Dhani	12	7.04	10.22	5.47	10.22	28.70	-0.05
Dehri	10	5.78	8.85	5.19	8.24	11.37	7.40
Harsolov	26	8.27	15.97	6.75	16.28	22.54	-1.87
Karwasaro Ki Dhani	10	8.78	12.22	6.91	12.42	27.06	-1.61
Khanwar	6	5.37	7.88	4.44	7.37	20.83	6.85
Lamba Jatan	9	7.42	12.16	6.25	11.80	18.64	3.09
Pundlu	13	6.79	11.88	5.20	11.11	30.70	7.00
Ratanga	11	4.88	7.17	4.22	6.75	15.66	6.15
Rohina	13	5.62	9.38	4.61	8.78	22.04	6.83
Somna	11	4.27	6.30	3.86	6.02	10.77	4.74
Tarnau	12	4.93	6.95	4.12	6.71	19.54	3.58
Total/average	144	6.40	10.32	5.28	10.01	21.20	3.05

3.2. Intercropping of dual purpose crops

Clusterbean was also grown under intercropping system as inclusion of legumes in the cropping system for increasing the quality of fodder (Plate 6). Intercropping of sorghum+clusterbean and pearl millet+clusterbean produced 63.5 q/ha and 58.7 q/ha dry matter yield, respectively. The total biomass production was lower in the intercropping as compared to sole sorghum (73 q/ha) and sole pearl millet (66 q/ha). The intercropping of clusterbean in sorghum and pearl millet did not increase the total dry matter production but quality of fodder and economic returns were higher with inter cropping system as compared to sole sorghum and pearl millet (Table 13). This was due to high price of clusterbean seed.

Sorghum+ Clusterbean Intercropping

Pearl millet + Clusterbean Intercropping

Plate 6: Intercropping of clusterbean with pearl millet and sorghum

Table 13: Effect of intercropping on grain and stover yield at farmer fields

Cropping system	Crops	Yield (q/ha)			Returns (Rs/ha)		
		Grain	Stover	Total	Grain	Stover	Total
Pearl millet + Gaur Inter cropping	Gaur	6.0	10.3	16.3	48000	4120	52120
	Pearl millet	10.0	32.4	42.4	12000	9720	21720
	Total	16.0	42.7	58.7	60000	13840	73840
Sorghum + Gaur Inter cropping	Gaur	7.0	12.2	19.2	56000	4800	60880
	Sorghum	14.0	30.3	44.3	14000	12120	26120
	Total	21.0	42.5	63.5	70000	17000	87000
Sole Crops	Sorghum	23.5	49.5	73.0	23500	19800	43300
	Pearl millet	18.0	58	66.0	21600	17400	39000
	Gaur	11.5	19	30.5	92000	7600	99600

3.3. Introduction of sweet sorghum and Napier hybrid during Kharif season

Napier hybrid grass was introduced at 6 sites for year round fodder production under irrigated conditions (Plate 7). Mean green fodder yield was 283 q/ha in first cutting (Table 15). Improved varieties of sweet sorghum (CSV 24SS/ CSH 22 SS/ CSV 84) were also grown at eight farmers' fields with fodder yield range of 275-453 q/ha (Table 14).

Plate 7 : Cultivation of Napier Bajra hybrid for fodder

Table 14: Fresh and dry matter yield of sorghum during *kharif* 2013

Village	Sorghum varieties								
	CSH - 22SS			CSV - 24 SS			CSV - 84		
	Fresh weight (q/ha)	Dry weight (q/ha	Plant height (cm)	Fresh weight (q/ha)	Dry weight (q/ha)	Plant height (cm)	Fresh weight (q/ha)	Dry weight (q/ha)	Plant height (cm)
Harsolav	300	110	150	410	170	147	220	90	153
B.K.D	350	100	172	440	130	164	190	50	127
K.K.D	460	200	205	540	210	204	380	100	167
Pundlu	270	110	181	420	200	209	310	120	185
Average	345.00	130.00	177	452.5	177.5	181	275	90	158

Table 15: Napier Hybrid *Kharif* 2013

Village	No of Demo.	Fresh Yield (I^{st} cut) q/ha	Dry Matter Yield (q/ha)	Plant height (cm)
Harsolav	4	283	118.3	210

4. Fodder crops during *rabi* season

4.1. Cultivation of barley and lucerne

During *rabi* season, 186 field trials on barley covering 55.8 ha were conducted on the farmers' fields from 2010 to 2014 (Table 16). Similarly, 95 trials were conducted on lucerne on 25.45 ha (Table 17). Seeds of barley varieties RD-2508, RD-2552 and RD-2035 were distributed to the farmers along with other critical inputs as per the recommendations of the district (Plate 8). The fodder yield of the demonstrations were compared with the farmers practice for impact analysis. Improved varieties of barley performed better both in terms of fodder and grain yield over farmers prevailing practices in all the villages under study. The grain yield of barley varieties varied from 37.34 q/ha to 44.68 q/ha with mean yield of 40.72 q/ha over the villages which was 14.65 per cent higher than the farmers practice (Table 16). Similarly fodder yield ranged from 46.22 to 58.61 q/ha with mean yield of 51.45 q/ha. The mean fodder yield was 17.05 per cent higher with improved practices than the farmers practice (43.99 q/ha). Under demonstrations of lucerne, variety Anand-2 was distributed to the farmers for supply of nutritious green fodder during winter and summer (Plate 8). In general, six cuts of the crop were taken at an interval of 25 days by the farmers from November to June. The

green fodder yield of lucerne was also recorded higher with improved practices than farmer's practices. The green fodder yield with improved practices ranged from 556 to 756 q/ha with mean yield of 637 q/ha. The increase in fodder yield with improved practices over farmers' practices was 15.02 per cent over the years (Table 17).

Table 16: Grain and straw yield of barley in different villages of Nagaur district during *rabi* season 2010-11 to 2013-14

Village	No. of Trials	Total area (ha)	Improved practices (q/ha)		Farmers' practices (q/ha)		Per cent increase in yield	
			Grain Yield	Straw Yield	Grain Yield	Straw yield	Grain Yield	Straw yield
Beetan	15	4.5	44.68	52.03	39.25	43.35	13.83	20.02
Bhatiyon Ki Dhani	14	4.2	37.34	52.99	32.00	44.19	16.69	19.91
Dehri	14	4.2	37.87	51.63	33.17	44.94	14.18	14.89
Harsolov	40	12	44.20	48.30	37.70	41.73	17.24	15.76
Karwasaro Ki Dhani	12	3.6	42.25	58.61	36.06	49.00	17.18	19.60
Khanwar	14	4.2	41.82	46.22	38.23	40.83	9.39	13.22
Lamba Jatan	8	2.4	40.37	55.03	34.50	48.57	17.02	13.30
Pundlu	15	4.5	42.09	50.04	37.60	42.00	11.93	19.12
Ratanga	15	4.5	38.91	46.46	33.45	37.96	16.32	22.40
Rohina	14	4.2	38.05	53.33	33.33	46.55	14.15	14.57
Somna	10	3	43.15	48.94	36.78	41.71	17.32	17.33
Tarnau	15	4.5	37.96	53.84	34.33	47.04	10.56	14.45
Total/Average	186	55.8	40.72	51.45	35.53	43.99	14.65	17.05

4.2. Introduction of oat and fodder beet during rabi season

Traditionally farmers of the region do not grow oat and fodder beet for feeding to their livestock under irrigated conditions. Under the project activities farmers were motivated to raise these fodder crops under irrigated conditions (Plate 8). Selected farmers were given exposure visit and other inputs initially for conducting demonstrations on 0.1 ha which later on increased to 0.2 ha. Thirty one demonstrations covering 5.60 ha on oat (Table 18) and 47 trials on 4.7 ha area under fodder beet (Table 19) were conducted during the project period at farmers' field. Seeds of oat variety Kent and fodder beet variety JK Kuber were given to the farmers for feasibility testing under the prevailing edaphic and climatic conditions. The green fodder yield of oat at two cuts ranged from 200 q/ha at Beetan to 430 q/ha at Bhation Ki Dhani with an average yield of

Table 17: Green fodder yield of lucerne during *rabi* season 2010-11 to 2013-14

Village	No. of trials	Total area (ha)	Green fodder yield (q/ha)		Per cent increase in yield
			Improved practices	Farmers' practices	
Beetan	6	1.60	713	636	12.07
Bhatiyon Ki Dhani	5	1.30	561	495	13.17
Dehri	7	1.90	611	510	19.72
Harsolov	16	4.20	645	548	17.63
K.K.D	5	1.35	685	591	15.98
Khanwar	5	1.30	556	485	14.61
Lamba Jatan	8	2.05	643	560	14.71
Pundlu	15	4.20	756	692	9.16
Ratanga	3	0.75	697	595	17.14
Rohina	12	3.35	574	486	18.01
Somna	6	1.65	609	535	13.91
Tarnau	7	1.80	591	508	16.43
Total/Average	95	25.45	637	553	15.02

296 q/ha. Similarly fresh tuber yield of fodder beet was 51 to 95 t/ha in addition to 5-15 t/ha green leaves. The fresh weight of individual tuber range was 1.5 -2.5 kg. The average tuber and green leaf yield was recorded 75.30 and 10.96 t/ha, respectively.

Table 18: Green fodder yield of oat during *rabi* 2010-11 to 2013-14

Village	No. of trials	Total area (ha)	Green fodder yield (q/ha)
Beetan	2	0.40	200
B.K.D	1	0.20	430
Dehri	1	0.20	230
Harsolav	16	3.00	335
K.K.D	1	0.20	310
Lamba Jatan	2	0.40	300
Pundlu	4	0.40	281
Rohina	4	0.80	282
Total/Average	31	5.60	296

Table 19: Fresh tuber and leaf yield of fodder beet during 2012-13 to 2013-2014

Village	No. of trials	Total area (ha)	Tuber yield (t/ha)	Green leaves (t/ha)
Beetan	3	0.30	70.00	8.00
B.K.D	2	0.20	95.00	15.00
Dehri	1	0.10	71.00	8.30
Harsolav	19	1.90	91.93	15.24
Khanwar	2	0.20	51.00	5.10
K.K.D	1	0.10	80.00	15.00
Lamba Jatan	3	0.30	93.00	15.00
Pundlu	3	0.30	60.00	10.00
Ratanga	4	0.40	81.25	10.28
Rohina	3	0.30	71.50	11.00
Tarnau	6	0.60	63.67	7.60
Total/Average	47	4.7	75.30	10.96

Lucerne (A-2)

Fodder beet

Barley (RD 2035)

Oat (Kent)

Plate 8: Cultivation of rabi fodder crops

5. Fodder crops during *summer* season

To study the improved fodder production technology under irrigated conditions 358 demonstrations of pearl millet, sorghum and clusterbean crops were conducted at farmers' fields of 10 villages. Improved varieties i.e. AVKB-19 and Rijka bajri of fodder pearl millet; CSV-20, MP Chari and SSG 778 of sorghum and Bundel clusterbean -2 of fodder clusterbean were grown with recommended practices to assess their suitability for fodder production (Plate 9) and to demonstrate improved forage cultivation technologies. Forage yield ranged from 319 to 430 q/ha of pearl millet with mean yield of 345 q/ha,

Sorghum

Rijka Bajri

Plate 9 : Demonstration of improved varieties of Sorghum and Pearl millet practices during summer season

301 to 465 q/ha of sorghum with mean yield of 382 q/ha and 118 to 134 q/ha of fodder clusterbean with mean yield of 126 q/ha at different villages (Table-20). Farmers showed keen interest specially in adopting Rijka bajri and Sorghum CSV -20 for their good quality of fodder.

Table 20: Green fodder yield of pearl millet, sorghum and clusterbean during summer 2011 to 2013

Village	Pearl millet		Sorghum		Clusterbean	
	No. of trials	Green fodder yield (q/ha)	No. of trials	Green fodder yield (q/ha)	No. of trials	Green fodder yield (q/ha)
B.K.D	15	327	2	388	2	130
Beetan	32	323	5	418	2	134
Dehri	22	337	11	340	1	118
Harsolov	45	323	22	428	2	125
K.K.D	19	347	1	385	2	133
Khanwar	1	430	-	-	-	-
Lamba Jatan	17	368	10	465	2	129
Pundlu	28	319	3	385	2	126
Rohina	57	342	11	301	4	123
Tarnau	26	329	7	331	7	119
Total/Average	262	345	72	382	24	126

6. Study of cropping sequences

Adoption of improved scientific crop management practices such as high biomass yielding varieties, judicious and balanced use of fertilizer and irrigation water, and proper cropping sequences helps in enhancing production of fodder. To assess the fodder production potential from different cropping sequences, demonstrations on improved cultivation practices of fodder crops during *rabi* and summer season under limited irrigation were conducted at farmers' fields. The total production of dry matter yield was higher in barley-sorghum sequence (1.82 t/ha) than lucerne-lucerne sequence (1.69 t/ha) and barley-pearl millet (1.53 t/ha) (Table 21).

7. Introduction of thornless cactus (*Opuntia ficus-indica*)

7.1. Performance of cactus pear at farmers' field

To provide green fodder to the animals during lean season, spineless cactus (*Opuntia ficus- indica)* as an alternative source of green fodder was also introduced at

Table 21: Dry matter production from different fodder crops sequences

Cluster	Cropping System	Dry matter yield (q/ha)				
		Barley	Lucerne	Sorghum	Pearl millet	Total
Harsolav	Barley- sorghum	93		98		191
	Barley- pearl millet	93			68	161
	Lucerne-lucerne		167			167
Lamba Jatan	Barley- sorghum	88		84		172
	Barley- pearl millet	88			57	145
	Lucerne-lucerne		170			170

fields of eight villages at nine locations (Plate 10). Initially the response of cacti was not satisfactory at all sites due to high mortality which might be due to rotting at the base of cladodes (Table 22). Per cent survival ranged from 16 to 50% at different locations. The growth of these plants was slow initially probably due to lack of moisture at some places.

Table 22: Performance of cactus pear at farmers' field

Cluster/Village	Month of planting	No. of cladodes planted	No. of cladodes survived	Survival percentage
Lambajatan-Poondlu	July, 2010	50	22	44
Lambajatan-Beetan	July, 2010	4	2	50
Harsolav-Gujro ki Dhani	July, 2010	10	3	30
Harsolav-Bhatiyo ki Dhani	March, 2011	32	7	21.9
Harsolav-Gaushala	March, 2011	14	4	28.6
Tarnau-Dehri	March, 2011	12	2	16.7
Tarnau	March, 2011	8	3	37.5
Rohina-1	March, 2011	15	5	33.3
Rohina-2	March, 2011	8	2	25
Total	-	153	50	31.89

7.2. Propagation trial in nursery: Effect of healing over period

The success of directly planted cladodes in field conditions was very poor both at research stations and farmers' field. Hence, efforts were initiated at CAZRI, Jodhpur for standardization of establishment techniques for rapid multiplication of suitable germplasm. The cladodes of different healing over periods (i.e. period after detachment from mother plant) were planted in big polythene bags (8" x 12") filled with sandy soil

and compost (5:1) during first week of March. Survival increased with the period of healing over from first week to four weeks (Table 23). The mortality of plants was low because of the rotting at the base of cladodes, the survival of plants further decreased after 4 months of planting in one and two weeks healing over period of planted cladodes. The plant height including the mother cladode was highest in those plants after two weeks of healing while it was almost same in one week and four weeks healing over cladodes. The number of new leaves formed and weight of new leaves were almost at par in all the treatments. Thus based on the study it may be concluded that for better results cladodes should be planted after four weeks of healing over period to get maximum number of rot free plantlets.

Plate 10: Performance of spineless cactus at farmers' fields and research station

Table 23: Performance of cactus propagation in nursery

Healing over period (week)	Per cent survival after planting		Plant height including new leaves (cm)	No. of new leaves formed	Weight of new leaves (g)
	2 months	4 months			
1	71	37	36.88	2.17	225.00
2	75	46	45.19	2.28	303.80
4	80	80	37.54	2.58	269.89

7.3. Propagation trial in nursery: Effect of irrigation level and genotype

The direct planting of cactus pear cladodes in the field followed by irrigation just after planting results in 80-90 per cent mortality due to rotting. Efforts were therefore, made to standardize the nursery techniques for its propagation. The rooting medium was prepared especially for cactus pear to prevent rotting. The medium was prepared by mixing soil and compost manure (7:1), saturated with water, left for 48 hours after which the entire mixture was pulverized by turning the soil ups and down by spade to aerate the media and it was allowed to dry for another 24 hours. Now partially dried mixture was filled in earthen pots. The moisture content of this mixture ranged from 7.77 to 8.77% as against 16.95 % in freshly irrigated soil of the same media. About six months (Y_1) and one year old (Y_2) cladodes of three genotypes (V_1=clone No.1270, V2=Clone 1308 and V_3=1271) were planted in pots during second week of February. No irrigation was given till 15 days after planting. Thereafter water of about one litre per pot was applied weekly.

The bud sprouting began after 25 days of planting. Tremendous reduction in rotting was observed due to moisture regulation and proper drainage in pots. 86 to 100 % rot free pants were found after four months of planting. Six-month-old cladodes showed 100 % rot free survival irrespective of variety as compared to one-year-old cladodes. The highest number of roots (32.33) was recorded in one-year-old cladodes of clone no.1270 and 1308 while root length was found maximum (10.50 cm) in case of six-month-old cladodes of clone No.1271. The fresh weight of the plant after the end of four months of planting indicated that in majority of the cases, there was net loss in weight as compared to initial fresh weight of the cladodes at the time of planting (Table 24). This implied that new growth including shoot and root biomass occurred from the use of reserved food material. The rot free rooted plants could be transplanted in the field after about 4 months of planting.

Table 24: Effect of variety (V) and cladode age (Y) on propagation of cactus pear after four months of planting in pots.

Treatments	Rot free survival (%)	No. of new leaves	No. of roots	Root length (cm)	%loss/gain in fresh weight after 4 months
Y_1V_1	100.00	2.67	32.33	8.17	+10.22
Y_1V_2	100.00	2.73	32.33	9.07	-2.30
Y_1V_3	100.00	3.07	22.67	10.50	-0.80
Y_2V_1	86.66	2.03	21.33	8.43	-2.70
Y_2V_2	86.66	1.00	21.00	7.17	-3.46
Y_2V_3	86.66	1.83	29.00	8.33	+4.61

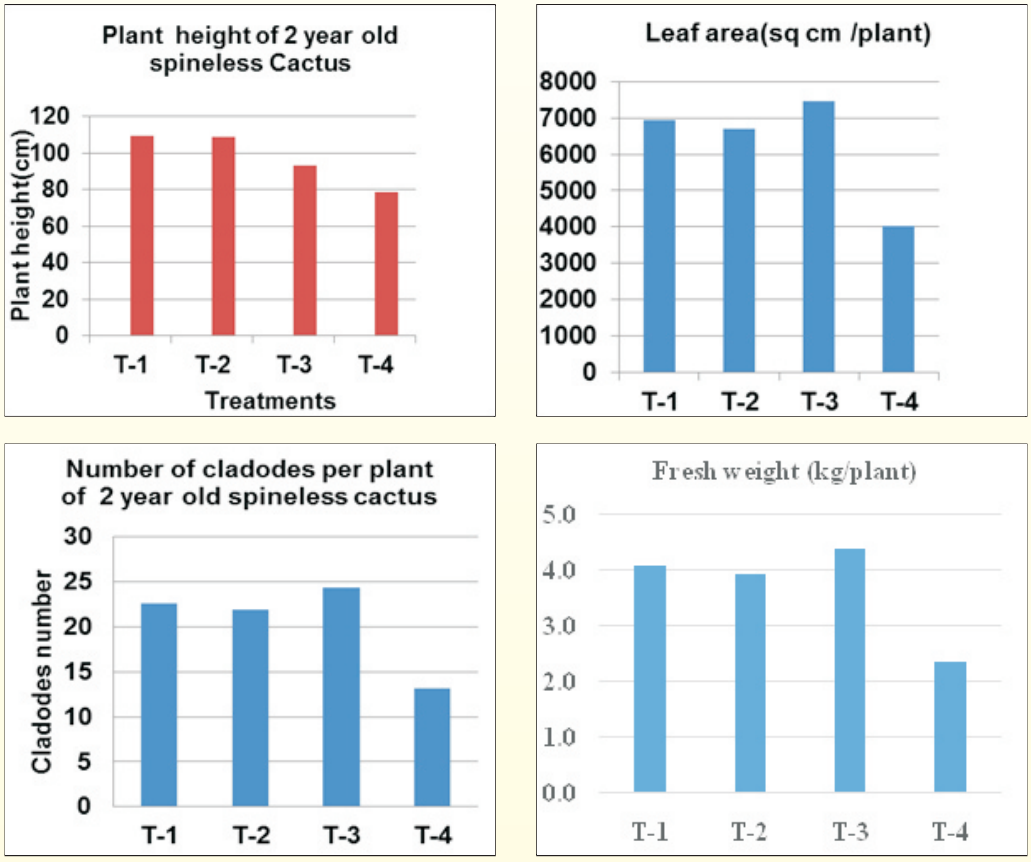
Where, V_1=Clone No. 1270, Y_1 =6 months (<600g), V_2=Clone No. 1308, Y_2=1 year (>600g), V_3=Clone No.1271

7.4. Performance of cactus pear at research field

Spineless cacti were planted in July, 2010 at CAZRI Farm to study the growth performance and water requirement (Plate-10). Watering was done at different intervals i.e. at 10, 20 and 30 days and control. Cacti planted in four rows with nine plants in each row. The depth of irrigation water was 5 cm and applied as per the time interval during summer season only. The plant height and number of cladodes per plant were higher in plants watered at 10 days interval as compared to 20 and 30 days intervals and control during the first year. The plant growth remained at par with each other during second year but found greater than control with intervals of irrigation (Fig 4).

8. Assessment of feeding of multi-nutrient-block to bovine

There are different means of supplementation of essential nutrients to the large ruminants, surviving mainly on grazing and partially with stall feeding of crop residues. The feeding of the blocks is a convenient and inexpensive method of providing a range of nutrients which may be deficient in the diet required by both rumen microbes and the animals. The complete feed block is one of the most appropriate means to supplement the energy, non-protein nitrogen in combination of minerals and vitamins. The different ingredients (Plate-11) are designed to provide a wide range of nutrition to cover all potential deficiencies (Table 25).



T-1 irrigation at 10 days intervals, T-2 irrigation at 20 days intervals, T-3 irrigation at 30 days intervals and T-4 Control (No water)

Figure 4: Effect of Irrigation levels on plant growth parameters of spineless cactus

Table 25: Composition and chemical constituents of multi-nutrient block

Ingredient (%)		Proximate component (%)	
Molasses	44.5	Dry matter	97.3
Urea	4.3	Organic matter	78.3
Common salt	4.3	Crude protein	22.9
Dolomite	4.3	Ether extract	4.1
Vitamin mineral mixture	4.3	Minerals	21.7
Wheat bran	32.1	Total carbohydrates	51.3
Clusterbean gum dust	1.0	Gross energy (kcal)	381
Clusterbean meal	5.1		

The feeding trials of MNB were conducted on lactating cattle and buffaloes at farmers' fields. 142 cows of 123 farmers and 253 buffaloes of 253 farmers were considered for the supplementary feeding trials in all 12 villages of both Jayal and Merta tehsils. Total 8-10 MNBs were provided to each animal for about 3 months during lactation in addition to farmers' practice. The MNBs were offered to the animals during stall feeding. The block was kept near the feed manger for the free access during the stall feeding. Initially more number of animals tended to bite the blocks, but after seeing its hardness they licked the blocks. One block was generally consumed by the animal within 7 to 10 days depending upon the need of the animal (Plate 12). This trial was designed for a particular micro-situation where farmers were unable to provide balanced ration to their animals due to unawareness and lack of essential nutrients. Animals in this situation met out their nutrient requirements mainly through grazing and stall feeding of dry fodder of crops residues. The concentrate feed prepared from locally available feed ingredients was also supplemented to the lactating animal as per the milk production level. The concentrate feeds are not often in balanced form, but deficient in some minerals and vitamins.

Plate 11: Various ingredients of multinutrient feed block

8.1 Effect of supplementation of MNB on daily milk yield of bovine

The effect of block licking was observed on milk yield of the animal. The average daily milk yield of cows and buffaloes were 5.85 and 7.65 liters, respectively, before the feeding of MNB, however after feeding on it, increase in daily milk yield was observed

Plate 12 : Feeding trials of multinurient- feed- block to bovine

just after 3-4 days. The average age of animals was 5.19 and 6.1 years for cows and buffaloes in different villages of Jayal and Merta Tehsil. The average parity number of cows and buffaloes was 2.74 and 2.17, respectively. The daily milk yield of cows and buffaloes, recorded by farmers in Milk Record Index Card, increased by 11.45% and 6.3%, respectively due to supplementation of MNBs (Table 26 - 27).

An increase of 5725 liters of milk yield was obtained from 142 cows of 12 villages in Jayal and Merta Tehsils due to feeding of MNBs for three months period and B: C ratio of this intervention was estimated to be 4.29 in cows (Table 26). In comparison to cattle, more number of buffaloes was taken in feeding trials since the buffaloes are main dairy animals in villages of Nagaur district. Supplementation of MNBs resulted in about 11772 liters more milk from 253 buffaloes in villages of both Tehsils. The B: C ratio of this intervention was estimated to be 4.95 in buffaloes (Table 27). The B: C ratio

Table 26 Effect of Supplementation of MNB on daily milk yield of cows in different villages of Jayal and Merta Tehsils

Village	Number of farmers	Number of Cows	Total input quantity (kg)	Pretreatment milk yield (l/day/head)	Post treatment milk yield (l/day/head)	Milk yield Increase over 13 weeks (l)	Input cost (Rs)	Benefit (Rs)	B:C ratio
Beetan	9	13	126	11.75	12.33	680	3150	16308	5.18
Bhatiyon ki Dhani	6	7	54	6.05	6.80	347	1350	8316	6.16
Harsolav	50	51	466	6.15	6.65	2580	11650	61915	5.31
Khanwar	5	5	48	6.61	7.38	263	1200	6312	5.26
Lamba Jatan	4	8	78	4.20	4.39	157	1950	3758	1.93
Pundlu	7	16	102	5.64	5.92	392	2550	9396	3.68
Ratanga	1	1	12	5.00	7.30	27	300	648	2.16
Rohina	20	20	207	3.77	4.06	584	5175	14021	2.71
Somna	11	11	84	4.96	5.71	410	2100	9840	4.69
Tarnau	10	10	103	4.40	4.71	287	2575	6876	2.67
Total/Average	123	142	1280	5.85	6.52	5725	32000	137390	4.29

Table 27: Effect of supplementation of MNB on daily milk yield of buffaloes in different villages of Jayal and Merta Tehsils

Village	Number of farmers	Number of buffaloes	Total input quantity (kg)	Pretreatment milk yield (l/day/head)	Post treatment milk yield (l/day/head)	Milk yield increase over 13 weeks (l)	Input cost (Rs 25/kg)	Benefit (Rs)	B:C ratio
Beetan	10	10	132	10.05	10.68	603	3300	16884	5.12
Bhatiyon ki Dhani	7	7	78	8.25	8.49	148	1950	4130	2.12
Dehri	24	24	264	7.36	7.87	1338	6600	37470	5.68
Harsolav	38	38	360	7.15	7.62	1884	9000	52757	5.86
Karwasaro ki Dhani	16	16	120	7.89	8.10	416	3000	11654	3.88
Khanwar	34	34	330	8.91	9.36	1731	8250	48474	5.88
Lamba Jatan	6	6	72	6.30	6.50	108	1800	3024	1.68
Pundlu	7	7	96	7.76	8.43	332	2400	9301	3.88
Ratanga	18	18	180	7.74	8.25	838	4500	23450	5.21
Rohina	39	39	397	5.75	6.14	1100	9925	30789	3.10
Somna	14	14	142	7.96	9.04	1413	3550	39553	11.14
Tarnau	40	40	491	6.65	7.16	1861	12275	52119	4.25
Total/Average	253	253	2662	7.65	8.13	11772	66550	329605	4.95

of this intervention was higher in buffaloes than cows. The return from increased milk yield was estimated to be of Rs 1,37,390/- in cows and Rs 3,29,605/- in buffaloes, respectively (Table 26-27). Therefore, the feeding of MNB to the large ruminants was found suitable under this micro-situation.

9. Feeding of multi-nutrient-mixture in goats

The feed requirement of small ruminants is mainly met by extensive grazing on common lands, degraded pasture, road side vegetation, etc. in arid regions, which often causes deficiency of certain nutrients especially in the scarcity period after monsoon withdrawal i.e. from November to June. In many areas with small flock of goats, only lactating goats are fed with top feeds of *loong* (*Prosopis cineraria*), *Pala* (*Ziziphus nummularia*) and other concentrate feed available at farmers' home. But in case of large flock size, the supplementation of either fodder or concentrate to the goats is not possible due to high cost of conventional concentrate feeds (cereal grain, bran, oil cakes etc.). Therefore, there is need to seek alternative supplements to improve the nutrition during scarcity period to sustain the productivity of goats. The multi-nutrient-mixture powder was formulated in the Feed Technology Unit of CAZRI using molasses, urea, common salt, vitamin-mineral mixture, dolomite, wheat bran, clusterbean meal and organic binder.

9.1. Effect of supplementation of MNM on daily milk yield of goats

The feeding trials of MNM were conducted on lactating goats at farmers' fields (Plate 13). Total 790 goats of 446 farmers in 12 villages of Jayal and Merta Tehsil were selected for the supplementary feeding trials. Total 10-12 kg of MNM were provided to each animal for about 3 months period during lactation in addition to grazing. The MNM were offered to the animals @ 100 g/day/goat after goats returned from grazing. The effect of nutrient mixture supplementation on milk yield of lactating goats was found significant. It was observed that the mixture was palatable and accepted by goats. The daily milk yield of goats was recorded by farmers in Milk Record Index Card. The average age of the goats was 3 to 5 years and daily milk yield ranged from 1.0 to 2.28 lit in different villages (Table 28). The improvement in mean daily milk yield was 17.6 %. In general farmers also reported improvement in kidding performance and twinning rates in supplemented fed goats.

A total of 17673 liters increased milk yield was obtained from 790 goats of 446 farmers in different villages of Jayal and Merta tehsils after feeding of MNM for three

Plate 13: Feeding trials of Multinurient- feed- mixture to goats

Table 28: Effect of supplementation of MNM on daily milk yield of goats in different villages of Jayal and Merta Tehsils

Village	Number of farmers	Number of goats	Total input quantity (kg)	Pretreatment milk yield (l/day/head)	Post treatment milk yield (l/day/head)	Milk yield increase over 13 weeks	Input cost (Rs)	Benefit (Rs)	B:C ratio
Beetan	43	52	501	2.28	2.45	772	11273	15440	1.37
Bhatiyon Ki Dhani	40	73	675	1.78	1.97	1224	15188	24480	1.61
Dheari	9	14	126	1.60	1.91	384	2835	7684	2.71
Harsolav	101	165	1341	1.40	1.59	3283	30173	65650	2.18
Karwasaro Ki Dhani	25	31	288	1.00	1.30	837	6480	16740	2.58
Khanwar	4	12	111	2.20	2.78	626	2498	12528	5.02
Lamba Jatan	41	112	1074	1.64	1.92	2945	24165	58896	2.44
Pundlu	38	96	870	1.60	1.92	3159	19575	63180	3.23
Ratanga	37	54	675	1.42	1.66	961	15188	19220	1.27
Rohina	42	62	622	1.37	1.49	626	13995	12520	0.89
Somna	15	19	201	1.65	2.00	588	4523	11760	2.60
Tarnau	51	100	969	1.21	1.46	2268	21803	45352	2.08
Total/Average	446	790	7453	1.59	1.87	17673	167693	353450	2.11

months period. The cost of extra milk yield was estimated to be Rs 3,53,450 (Table 28). The B: C ratio of this intervention was 2.11 in goats. The introduction and use of high energy MNM feed as an alternative supplement containing high energy ingredients, non-protein nitrogen substance and vitamin mineral mixture resulted in a significant improvement in dry matter intake from grazing, water intake and consequently improved milk yield and overall health of the animals. Thus MNM was found a suitable economically viable option to supplement deficient nutrients in goats and sustain the productivity during feed scarcity period.

10. Assessment of feeding of urea treated fodder

The verification trial of enriching poor quality fodder through urea treatment was conducted at farmers' field. The acceptability of urea treatment to roughage gradually increased for the large animals as the farmers came to know the importance of this technology especially for dry areas. The crop residues of wheat, pearl millet and sorghum in dry form are main source of roughage for large ruminants in the area and are generally poor in protein with low palatability and digestibility. Therefore, urea treatment of fodder was found to be simple and useful technique to improve the nutritive value and palatability of these poor quality fodder. Further to improve the palatability and acceptability a minor modification was done by adding small quantity of jaggary in treated fodder before feeding to the animals and sometimes mineral mixture or common salt was also added. The jaggary @ 50g/kg treated fodder was added by mixing in water. The demonstration for fodder treatment was conducted at 426 farmers' fields in all clusters to create awareness about this technique and about 43 tons of wheat straw was treated under this technique and 426 animals were benefited from feeding of urea treated straw (Table 29**)**. The acceptability of this treated fodder was initially low in animals but later on it increased. Farmers found this technique more useful in maintaining the heifers and non-lactating animals. This technique is low cost, easy to understand and feasible under field conditions (Plate 14). The positive effect in animals was observed by feeding urea treated fodder (Plate 15). It was also observed that animals increased intake of dry matter and water. Farmers also reported that due to feeding of this treated fodder animals became healthier and more productive. Long term feeding trials of urea treated fodder in cattle was conducted in Sant Bhuria Baba Gaushala at Harsolav village and it was observed by the Gaushala workers that cows preferred treated fodder in comparison to untreated dry fodder.

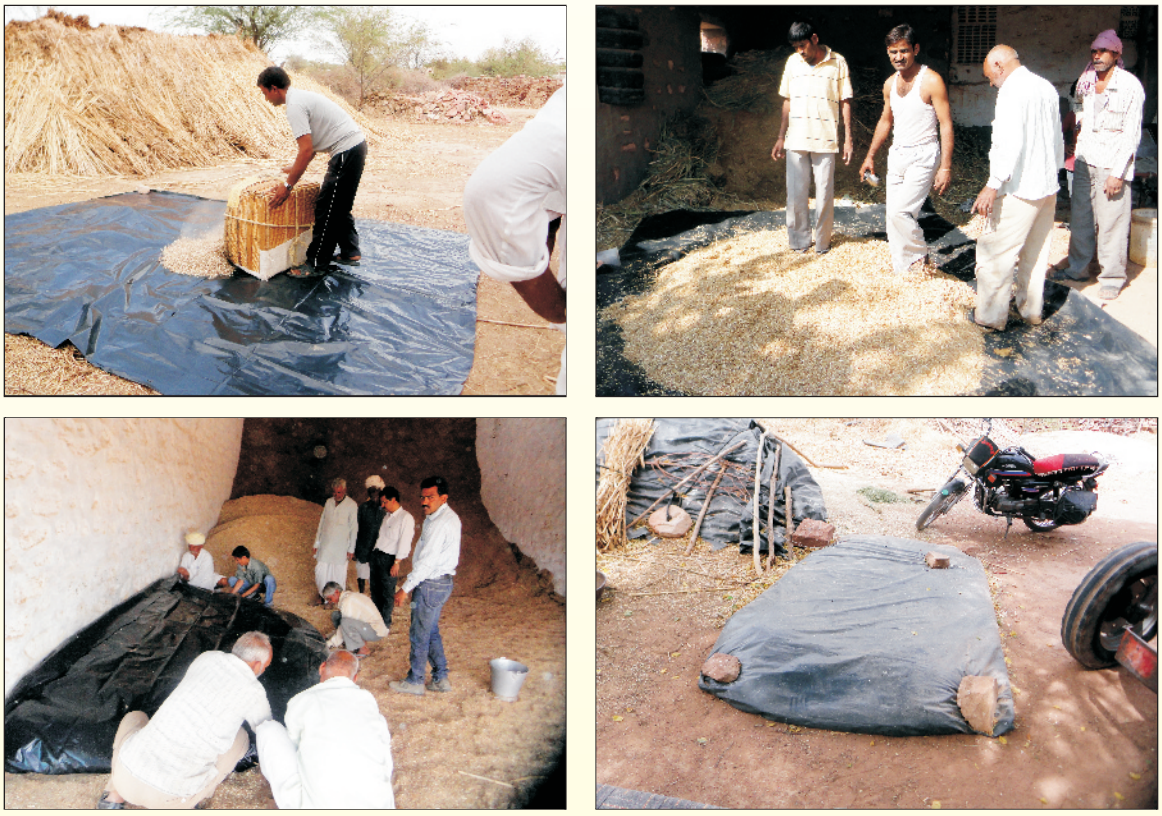


Plate 14: Demonstrating urea treatment of low grade forages

Table 29: Number of demonstration and urea treatment to fodder in different villages

Name of villages	No. of demonstrations	Quantity of straw treated (tons)
Beetan	31	3.1
B.K.D	43	4.3
Dehri	39	3.9
Harsolav	56	5.6
Khanwar	22	2.2
K.K.D	24	2.4
Lamba Jatan	29	2.9
Pundlu	34	3.4
Ratanga	25	2.5
Rohina	44	4.4
Somna	26	2.6
Tarnau	53	5.3
Total	426	42.6

Plate 15: Feeding of urea treated fodder

To facilitate regular urea treatment of a large quantity of fodder, two *pucca* tanks of 10' x 4' x 2.5' feet size were constructed in Gaushala with the capacity of 8 to 10 quintals fodder. The roughage mainly available for the enrichment was wheat straw and chaffed fodder of pearl millet.

11. Preparation of complete feed blocks

The Complete Feed Block (CFB) machine with feed-fodder mixture and feed grinder has been installed at Sant Bhuria Baba Gaushala, Harsolav village (Plate 16). The main aim of this technology is to add value in the poor quality roughages and feeding of complete feed blocks during scarcity and drought period of arid region of the country. These fodder blocks helped animals to maintain their health and production during feed and fodder scarcity. Poor quality crop residues could be converted into mineral and protein rich quality feeds. These blocks comprised all the essential feed ingredients in suitable

proportion and can be fed to productive animals as complete ration. For preparing CFB, 70% straw, 10% molasses, 10% wheat bran, 2.5% clusterbean meal, 1% dolomite, 1% urea, 1% salt, 1% mineral mixture and 3.5% water were used. The complete feed block on dry weight basis contained 83.7% organic matter, 11.8% crude protein, 4.5% ether extract, 16.3% minerals, 67% total carbohydrates and 389 kcal gross energy. This field trial of complete feed block has been initiated first time at farmer's door in the arid area of Rajasthan with active participation of people. Large number of farmers from 12 villages benefited from the technology. The total expenditure of Rs 10 lakhs for installing the machine would be met by paying nominal charges of rupee one per block (4 kg) which also includes the electricity and operational cost of the machine. Machine has capacity to produce 25 blocks each of 4 kg of weight in one hour time (100 kg/hr). Total of 9708 complete fodder blocks were prepared from the machine since its installation at the project site in 2011 benefiting 51 farmers including of two Gaushala (Plate 17). The straw used in preparation of fodder blocks was brought by the farmers and ingredients were supplied from the project. The cost analysis for preparing of CFB is given in the Table 30.

Plate 16: Establishment of complete fodder block machine at Sant Bhuria Baba Gaushala, in Harsolav village

Plate I7 : Preparation of complete fodder block at Sant Bhuria Baba Gaushala, in Harsolav village

CAPACITY BUILDING OF THE FARMERS

To develop awareness about project activities among farming community different extension methods were used for communication (Table 31). The group discussions were held with the farmers regarding the activities taken at farmers' field in each village at regular interval (Plate 19). Total 33 group discussions were organized on different interventions such as improved techniques of silvi-pasture, fodder crops, cactus propagation, multi-nutrient blocks/mixture and urea treatment of dry fodder for increasing the forage production and livestock productivity. About 755 farmers participated in these group meetings during July 2010 to March 2014.

Five exposure visits of farmers of adopted villages were organized to visit the CAZRI campus at Jodhpur (Plate 18). Farmers could see all the fields of silvipasture, arid horticulture, cactus plantations, arable *kharif* crops, irrigated *rabi* fodder crops, animal

Table 30: Cost analysis of complete fodder block preparation (100 kg raw material)

Ingredient	Quantity (kg)	Cost/unit (Rs/kg)	Total cost (Rs)	For 100 kg raw material for making 25 blocks of 4 kg block
Straw	70.0	3	210	
Wheat bran	10.0	14	140	
Clusterbean korma	2.5	22	55	
Jaggery	10.0	30	300	
Urea	1.0	6	6	
Salt	1.0	2	2	
Dolomite	1.0	4	4	
Mineral mixture	1.0	50	50	
Water	3.5	0		
Total			767	
a. Cost of 25 blocks with cost of straw			767	
Cost per block of 4 kg			30.70	
b. Cost of 25 blocks excluding cost of straw			557	
Cost per block of 4 kg			22.28	
c. Cost of 25 blocks (a) + electricity			792	
Cost per block of 4 kg			31.70	
d. Cost of 25 blocks (a) + labour			817	
Cost per block of 4 kg			32.70	
e. Cost of 25 blocks (a) + electricity + labour			842	
Cost per block of 4 kg			33.70	

feed technology unit, arid breeds of cattle, goats and sheep, etc. Farmers were acquainted with the latest technologies, which can help them to understand the recent developments and adopt the new & useful techniques. About 295 representatives of farmers groups participated in these activities.

Table 31: Extension Activities

Project activities	Achievements	Farmers benefited
Exposer visit	5	295
Field day	5	1320
Group discussion	33	755
Method demonstration	9	150
Training	12	435
Total	64	2955

Plate 18 : Exposure visit of farmers - farmers examining thornless cactus (*Opuntia ficus-indica*) at horticulture field, CAZRI Jodhpur

Twelve off-campus trainings were organized during 2010 to 2014 for creating awareness among the farmers of villages under the project regarding forage production and scientific feeding management of livestock (Plate 20). Off- campus trainings were conducted on improved feeding and management system of livestock; supplementary feeding to the animals through MNM, MNB; cultivation of dual-purpose and fodder crops during *kharif* and *rabi* season, and cultivation of summer fodder crops. About 435 farmers and farm women were benefited through these training programmes.

Nine method demonstrations on different techniques were conducted in different villages for adoption of improved farm technologies. Demonstration on sowing of grass seed in 2 ha area for pasture development was done in Harsolav village. Demonstration on sowing of grasses on field bund for pasture production was done in Rohina, Harsolav and Beetan villages. Practical trainings of urea treatment of dry fodder, establishment of

badi (orchard), budding and pruning in ber plants at farmers' fields were also conducted. Demonstrations on planting technique of fodder beet and Napier hybrid and fertilizers application in fodder crops, complete fodder block preparation using block making machine at Gaushala were also conducted.

Plate 19 : Group meeting with farmers

Five field days were organized in Harsolav cluster for creating awareness regarding all ongoing activities of the project and livestock centric interventions for mass communication (Plate 20). All consortia partners participated in these field days. About 1320 farmers participated in these field days and they were benefited with improved agricultural technologies by experts from CAZRI, RLDP and GVT. A small exhibition on project activities was also placed in the programme. Farmers and experts visited the field demonstration of pasture grasses and fodder crops (Plate 21).




Field day

Farmers' training

Plate 20: Creating awareness among farmers

SUMMARY

Pilot study on *Livestock Centric Intervention for Livelihood Improvement in Nagaur district of Rajasthan*" is an externally funded project in consortia mode involving Rajasthan Livestock Development Board (RLDB), Central Arid Zone Research Institute (CAZRI) & Gramin Vikas Trust (GVT). This project was sponsored by NRAA, Planning commission, Govt of India for the period of four years i.e. from 2010 to 2014. This project aimed to moderate risk, provide resilience, diversify livelihood option and create resources which can be liquidated during calamities. The focus was on strengthening livestock production as central intervention and build other enabling conditions around this activity. A total of 12 villages in four clusters of two Tehsils namely Jayal and Merta had been selected for the implementation of project activities. One thousand households

Plate 21: Visit of experts and dignitaries

from each cluster had been selected for the study after completing the socio-economic survey. CAZRI technological models were demonstrated for enhancing the biomass production through developing silvipasture, use of dual purpose coarse cereal varieties and cultivation of green fodder crops under limited irrigation. Introduction of spineless cactus as an alternative feed resource was also explored. Feed technologies related to need based supplementations: use of multi-nutrient feed block/feed mixture and complete feed block were implemented as per livestock species. Large quantities of low grade roughage and crop residues were enriched by simple urea treatment. The outcome of project increased availability of forage and overcome the deficiency of critical nutrients in dairy animals and enhanced their productivity.

To create awareness about pasture development, the demonstrations on planting techniques of *Cenchrus ciliaris and C. setigerus grasses* were conducted at 75 sites covering an area of 37 ha. The average *dry fodder yield from pasture varied from 2.4-2.8 t/ha.* These grasses were also sown in association with fodder trees in silvipasture system. During *kharif* season demonstrations on improved varieties of dual-purpose crops i.e. pearl millet, sorghum and clusterbean were conducted at 264, 249 and 144 farmers' fields, respectively on about 164 ha. The grain and fodder yields of improved cultivars were more by 21 and 14.32% in pearl millet, 25.38 and 15.93% in sorghum and 21.2 and 3.05% in clusterbean, respectively. During *rabi* season, 186 field trials on barley covering 55.8 ha were conducted on the farmers' fields. Similarly, 95 trials were conducted on lucerne on 25.45 ha. *During rabi season grain and straw yield* of barley increased by 14.65 and 17 %, respectively due to improved practices. Similarly green fodder yield of lucerne also increased by 15% due to improved practices. Fodder beet and oat (Kent) were also introduced at farmers' fields to increase green fodder availability. A sum of 31 field trials covering 5.6 ha on oat and 47 trials on 4.7 ha area under fodder beet were conducted during the project period. Improved varieties of sorghum, Rijka-bajri and clusterbean were grown at 358 farmers' fields during summer season for increasing availability of green fodder.

The feeding trials of multi nutrient feed block (MNB) were conducted on 395 lactating cattle and buffaloes belonging to 376 farmers. The response of MNB was positive in daily milk yield of cattle and buffaloes. Similarly, 790 goats of 446 farmers were supplemented with Multi Nutrient Mixture (MNM). The average daily milk yield increased by 5.85 to 6.52 litres in cattle and 7.65 to 8.13 litres in buffaloes due to feeding

of MNB. The increase in daily milk yield in cattle and buffaloes were 11.45 and 6.33% with B: C ratio 4.29 and 4.95, respectively. Similarly increase in average daily milk yield was 17.6 % in goats with B: C ratio 2.11 due to feeding of MNM. Trials on enriching of poor quality fodder through urea treatment were conducted at 426 farmers' fields and total 42 tons of straw was treated. Acceptability of urea treatment of roughage was good among the farmers as this technique is low cost, easy to understand and feasible under field conditions. In addition to this, 9708 complete fodder blocks of 4 kg each were prepared in farmers' participatory mode and used by 51 farmers for feeding their animals. The response of farmers was very encouraging, as more number of farmers are now coming themselves with straw for making fodder blocks. All these interventions helped in improving the feeding conditions in farmers' fields for all livestock species. The project results were very encouraging and reiterated the fact that livestock centric approach is ultimate way to improve the animal productivity in rainfed regions of the country.

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