भाकृअनुप
ICAR

Fodder Resources Development Plan for Rajasthan

भा.च.चा.अ.सं.
IGFRI

ICAR- Indian Grassland and Fodder Research Institute
Jhansi-284 003 (UP) India

An ISO 9001:2015 Certified Institute

Sardar Patel Award for Outstanding ICAR Institute (Large) for 2015

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त्रिलोचन महापात्र, पीएच.डी.
सचिव एवं महानिदेशक
TRILOCHAN MOHAPATRA, Ph.D.
SECRETARY & DIRECTOR GENERAL

सत्यमेव जयते

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MESSAGE

It gives me immense pleasure to learn that the State specific "Fodder Resources Development Plan" has been developed by the ICAR-Indian Grassland and Fodder Research Institute, Jhansi, for Rajasthan in consultation with all the stakeholders. Agriculture is the major source of livelihood security and potential source of rural employment in the State. The State is facing acute shortage of fodder which is the most important component in livestock development. There is shortage of 32.7% of green fodder and 42.1% of dry fodder requirements in the State which hampers the livestock production. This plan provides the technological options to enhance production, conservation and value addition of fodder.

I complement the ICAR-IGFRI, Jhansi for their meticulous efforts in bringing out this comprehensive fodder plan for the State of Rajasthan. I am quite confident that this document will guide fodder development and promotion activities in the State.

(T. Mohapatra)

Dated the 24th March, 2021
New Delhi

Acknowledgement

Fodder plan is area specific strategy to be adopted to overcome deficiency of green and dry fodder of the region and also to provide executable plan for the state government and other agencies involved in livestock related policy and planning. The fodder resource development plan provides technological options available for enhancing production, conservation and value addition of fodder resources of the state.

Looking into shortage of green and dry fodder in the country the idea and vision of the development of state wise fodder plan for different states of the country was visualized by Dr. Trilochan Mohapatra, Hon'ble Secretary DARE and Director General, ICAR. During his visit to IGFRI-SRRS, Dharwad on 17th June 2019, he advised to develop state wise fodder resource development plan which covers the broad areas as per requirement of the state. We are highly grateful to him for his insight guidance, encouragement, continuous support and suggestions in preparation of this document. We are also thankful to Deputy Director General (Crop Science), ADG (FFC) and other officers of the ICAR who extended their support during the development of fodder plan of Rajasthan.

We express our sincere thanks to Government of Rajasthan, especially to Dr. Pradeep Saraswat, Addl. Director (Farm & Estate), Animal Husbandry Department, Government of Rajasthan, and Dr. Ram Gopal Sharma, Jt. Director Input, Directorate of Agriculture, Government of Rajasthan, who actively involved in the interactive workshop held online on 10th July, 2020. They gave their valuable suggestions for fodder resource development in the state and stressed for adoption of recent technologies by the farmers and development of Model Fodder Production farms. We also extend our thanks to Dr. J.S. Sandhu, Vice Chancellor, SKNAU, Jobner (Rajasthan); Dr. Vishnu Sharma, Vice Chancellor, RAJUVAS, Bikaner (Rajasthan); for their valuable inputs in interactive workshop and showing keen interest in developing plan for augmenting forage and livestock sector in the state with special focus on pasture development on waste lands and impart training to state government officers. We also thank to other participants including officials of state government, KVK personnel, veterinary officials, etc., who actively participated in the workshop and provided their valuable suggestions for the improvement of plan.

The efforts made by our team from ICAR-IGFRI, Jhansi in preparation of fodder plan for the state of Rajasthan and organizing interactive workshop are praise worthy. This fodder plan is prepared as a part of the activities of our programme 'National Initiatives on Accelerating Fodder Technology Adoption (NIAFTA)', whole team of the programme and Nodal Officer, Dr Purshottam Sharma, Principal Scientist, deserves special appreciation.

(Vijay K Yadav)
Director (Acting)
ICAR-IGFRI, Jhansi

Fodder Resources Development Plan prepared as a part of

National Initiative for Accelerating Fodder Technology Adoption (NIAFTA)

ICAR - Indian Grassland and Fodder Research Institute, Jhansi

Themes of NIAFTA

- Developing State Fodder Resources Development Plan
- Disseminating fodder production technologies for enhanced productivity and improved management.
- Promoting alternate land usage
- Focusing fodder based rationing
- Utilizing fodder processing technologies for value addition.

Coordination Team

- Dr VK Yadav, Director — Chairman
- Dr. Purushottam Sharma, PS — Nodal Officer

Members

- Dr. AK Roy, Project Coordinator, AICRP on FC&U
- Dr. AK Mishra, Head, Plant Animal Relationship Division
- Dr. Sunil Kumar, Head, Crop Production Division
- Dr. RV Kumar, Head, Grassland & Silvipasture Management Division
- Dr. PK Pathak, Head, FMPHT Division
- Dr. Khem Chand, Head, Social Science Division
- Dr. Shahid Ahmad, Head, Crop Improvement Division

Rajasthan Fodder Resources Development Plan Committee

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- Dr. S S Meena, Chairman
- Dr. R P Nagar, Member
- Dr. D R Palsaniya, Member
- Mr. H S Meena, Member

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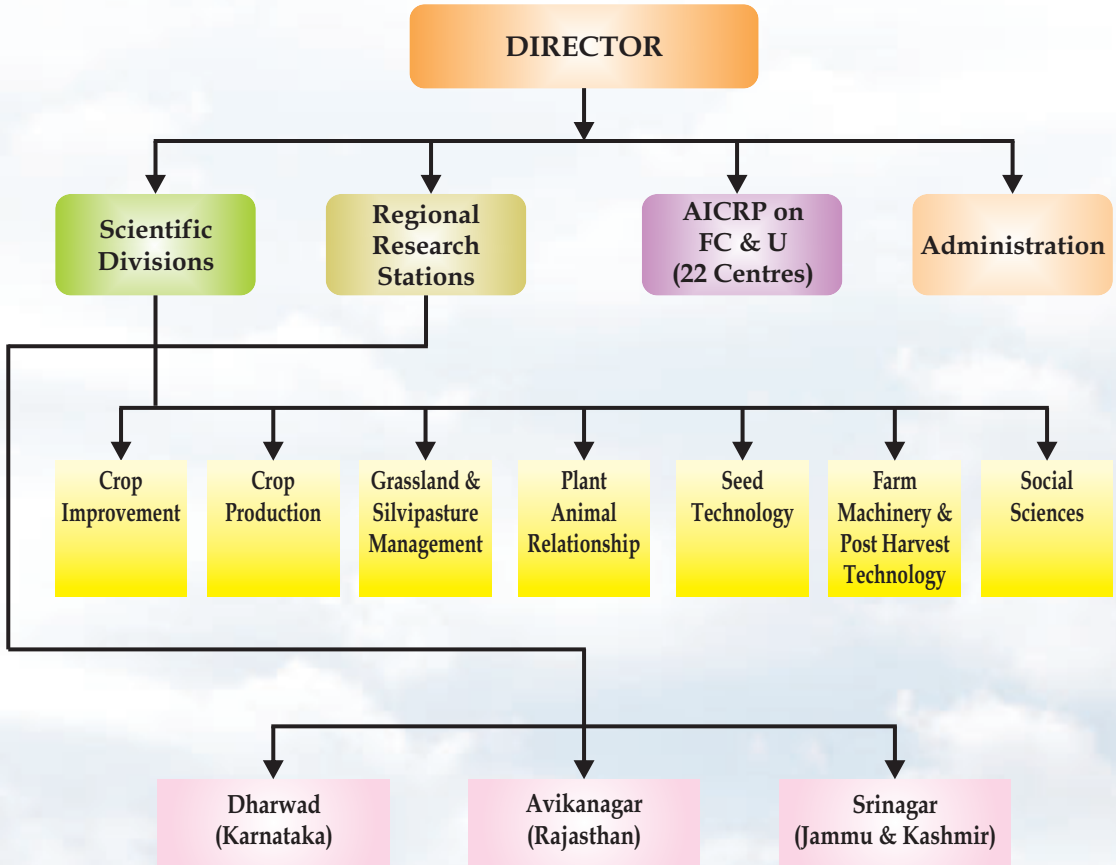
Organogram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ICAR-IGFRI - A Profile

ICAR-Indian Grassland and Fodder Research Institute, Jhansi (U.P) India

The ICAR-Indian Grassland and Fodder Research Institute (ICAR-IGFRI), Jhansi, was established in 1962 to conduct organized scientific research on grasslands and fodder production, conservation and their utilization. On 1 April, 1966, it became part of the Indian Council of Agricultural Research (ICAR). Subsequently All India Coordinated Research Project on Forage Crops and Utilization was started in 1972 with ICAR-IGFRI, Jhansi as head quarter for multi-location testing of forage varieties and technologies in different agro climatic zones of the country through 23 coordinating centers and 15 as volunteer centre's at various State Agricultural Universities/NGO/ICAR under the National Agricultural Research System. The institute consists of seven multi-disciplinary division *viz.*, Crop Improvement, Crop Production, Farm Machinery and Post-Harvest Technology, Seed Technology, Social Science, Grassland and Silvipasture Management and Plant Animal Relationship. It also has five units *viz.*, PME, HRD, ATIC, ITMU and AKMU and facilities like Library, Central Research Farm, Dairy and Central Instrumentation Lab. The institute has three regional stations located in Avikanagar (Rajasthan), Dharwad (Karnataka) and Srinagar (Jammu & Kashmir) to conduct focused forage research on arid, semi-arid and temperate climatic conditions, respectively and a grassland center at Palampur (Himachal Pradesh).

Mandate

- Basic strategic and adaptive research on improvement, production and utilization of fodder crops and grasslands.
- Coordination of research on forages and grasslands for enhancing productivity and quality for enhancing livestock productivity.
- Technology dissemination and human resource development.

The institute has successfully served the country for 58 years achieving several milestones in generation of fodder technologies. Institute was conferred with "Sardar Patel Outstanding ICAR Institution Award in the year 2015" for his remarkable progress and contributions in the field of forage research, capacity building and infrastructure development. Institute is an ISO 9001: 2015 certified institute. The institute is endeavoring in basic and applied research in both cultivated as well as range species in the fields of intensive fodder production systems, alternative fodder sources, grasslands, silvi and horti-pasture systems, seed production technology, farm mechanization, post-harvest conservation and utilization, livestock feeding and

management, etc. Institute is striving through numerous research projects at various levels like institute, inter-institute, externally funded national and international collaborative projects to address the persistent problems of fodder shortage and lack of quality forages. The institute is undertaking several new initiatives in forage research in new frontier areas.

Proven Technologies of Institute

- No. of forage varieties released: >300
- Climate resilient forage production systems under rainfed situation
- Round the year fodder production system (Irrigated situation)
- Round the year fodder production system (Rainfed situation)
- Fodder on Field boundary/Bunds/Channels
- Alternate land use systems
- Silvo-pasture model for highly degraded/ waste lands
- Horti-pastoral model for higher income in rainfed ecosystem
- Azolla as supplement feed for livestock
- Silage for sustenance of livestock production
- Community pastureland development
- Fodder production in mango orchards
- Improved varieties of grasses and cultivated fodder
- Seed production technology for all important forages
- Seed quality and field standards of forage crops
- DUS guidelines for forage crops.

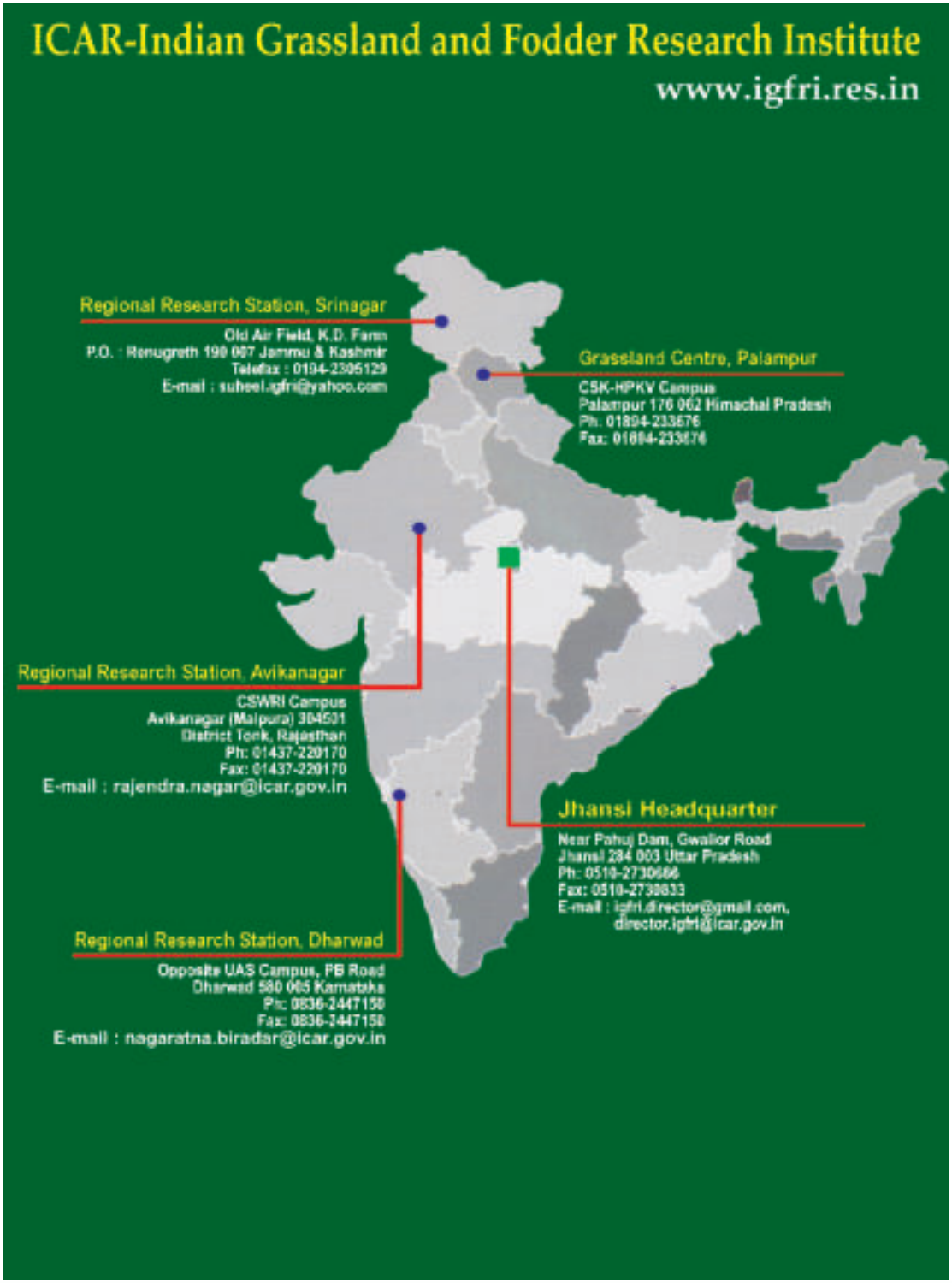
Accelerating Fodder Technology adoption

Transferring knowledge and skills are the essential component required for execution and implementation of resource conservation based projects in the country. The institute is organizing training and skill development programmes regularly of varying duration for farmers, students, state government officials, field functionaries in the field of soil and water conservation The research institutes has signed MoUs with more than 20 Gaushalas for transfer fodder production technologies. Field demonstration on validated technologies for resource conservation and productivity enhancement in red soils of Bundelkhand region are operating at full fledge. Several outreach programmes such as Adarsh Chara Gram A cluster of three villages, Mera Gaon Mera Gaurav (MGMG), National Initiative on Fodder Technology Demonstration (NIFTD), Network Project on Bhadawari Buffaloes, Participatory Fodder Production in Mango Orchards, Farmers FIRST Programme, NICRA, TSP, SCSP, NEH, DFI-Kisan Mitra and NIAFTA have been initiated and implemented.

ICAR has established in institute the Agri-Business Incubation Centre (ABIC) to provide technical knowhow to farmers, educated rural youth and develop entrepreneur.

NIAFTA: New Initiatives

Institute has initiated "National Initiative for Fodder Technologies Adoption (NIAFTA)" to formulate an implementable fodder resource development plan for each state/UT of the country suitable to specific niches which can utilize the potential of available resources to achieve self-sufficiency in fodder production and utilization. NIAFTA also aims for extension of latest research findings/technologies with the policy planners, management personnel and field level functionaries for enhancing country's fodder productivity, capacity building and skill enhancement of the fodder producers and livestock keepers on emerging technologies and also provide opportunity to interact with scientists and managers and impact assessment on fodder supply and farmers livelihood.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Part-I : Agriculture, Livestock and Fodder Scenario

A. Introduction

Rajasthan is the largest state of the country that has an area of 342,239 square kilometers which is around 10.4 per cent of India. The State is covering arid Great Indian Desert and parts of semi-arid climate zone. It faces severe water scarcity, has poor rainfall and weather is arid and hot and large portion of terrain is dry. Due to unstable weather conditions farmers have to depend on both rainfed and ground water agriculture. The agricultural year in the state covering the period from 1st July to 30th June is divided into three seasons *viz*, *kharif, rabi* and *zaid.* Eighty percent of the total population resides in rural area and largely dependent on agriculture as the source of their livelihood and 22.5 percent of state's GSDP comes from agriculture. Rajasthan has cultivated area of almost 20 million hectares but due to severe water scarcity only 20% of the total cultivated area is irrigated.

Figure 1: Location of Rajasthan state

The total human population of Rajasthan in 2011 is 68.55 million and the population density is 200 per sq. km. The livestock population of the state as per 2012 livestock census is 577.32 lakh. Animal husbandry and livestock is highly potential sector contributing a lot in state economy, especially of rural economy. The potential of crop production depends upon huge investment and weather conditions. Comparatively Animal husbandry and livestock is more stable and requires lesser investments. Livestock and poultry have proved to be life saviour in many distress conditions, especially in case of drought. Animal Husbandry is not only a subsidiary occupation to agriculture but it is a major economic activity, especially in the arid and semi-arid regions of the Rajasthan. Livestock sector development has a significant beneficial impact in generating employment and reducing poverty in rural areas. Livestock also provides large portion of draft power for agriculture.

India contributes about 18% world's livestock population, while it has only 0.5% grazing area. The pasture lands covers about 4.0% of geographical area (12 million ha) of the country with high grazing intensity (12.6 ACU/ha). Western India covers about 4.36 lakh km^2 which represents one-fourth of total arid and semi-arid regions of the country and

these regions extend over 61% and 13% in Rajasthan, 20% and 9% in Gujarat respectively, of total area of the state. Out of total area of Rajasthan and Gujarat, 40% and 30% area are available as grazing lands and 5.4% and 3.5% under permanent pasture respectively. The over-grazing has resulted in grassland deterioration and desertification. Therefore, rejuvenation/ establishment of improved grasslands and systematic utilization of pasture lands would facilitate sustainability of livestock production in western region.

Table 1. Land use scenario of Rajasthan in India (2013-14) (000 ha)

S.No.	Items	India	Rajasthan	Share of Rajasthan (%)
1.	Geographical area	328726	34224	10.41
2.	Forest	71828	2758	3.84
3.	Land not available for cultivation	43860	4274	9.74
4.	Fallow land	24848	3250	13.08
5.	Net area sown	141428	18268	12.92
6.	Total cropped area	200859	26120	13.00
7.	Cropping intensity	142	143	
8.	Cultivable land	181850	25542	14.05

(Source : Rajasthan Agricultural Statistics at a Glance, 2016-17)

B. Agro-climatic zones of Rajasthan

On the basis of major climates suitable for a certain range of crops and cultivars, the Rajasthan State is divided in 10 Agro-climatic zones (Figure 2). Relevant information of the zones is given below.

Table 2. Description of agro-climatic zones of Rajasthan

S.No.	Name of area	Total area (mh)	Districts covered	Rain fall (mm)	Temperature (°C)	Major Crops	Type of soils
1.	**IA-** Arid western plain	4.74	Barmer & part of Jodhpur	200-370	Max. 40 Min. 8.0	Pearl millet, Mothbean, Sesame, Wheat, Mustard, Cumin	Desert soils, sand dunes, aeolian soil coarse sand in texture some places calcareous
2.	**1B-** Irrigated north western plain	2.10	Sriganganagar, Hanumangarh	100-350	Max. 42 Min. 4.7	Cotton, Clusterbean Wheat, Mustard, Gram	Alluvial deposits calcareous, high soluble salts & exchangeable sodium, Desert soils and sand dunes aeolian soil, loamy coarse in texture & calcareous

3.	**IC-** Hyper arid partial irrigated zone	7.70	Bikaner, Jaisalmer, Churu	100-350	Max. 48 Min. 3.0	Pearlmillet, Mothbean, Clusterbean, Wheat, Mustard, Gram	Desert soils and sand dunes, aeolian soil, loamy coarse in texture & calcareous
4.	**IIA-** Internal drainage dry zone	3.69	Nagaur, Sikar, Jhunjhunu, Part of Churu	300-500	Max. 38 Min. 5.3	Pearlmillet, Clusterbean, Pulses, Mustard, Gram	Sandy loam, shallow depth red soils in depressions
5.	**IIB-** Transitional plain of Luni basin	3.00	Jalore, Pali, Part of Sirohi, Jodhpur	300-500	Max. 38 Min. 4.9	Pearlmillet, Clusterbean, Sesame, Mustard, Gram	Red desert soils in Jodhopur, Jalore & Pali; sierozems in Pali & Sirohi
6.	**IIIA-** Semi arid eastern plains	2.96	Jaipur, Ajmer, Dausa, Tonk	500-700	Max. 40 Min. 8.3	Pearl millet, Clusterbean, Sorghum, Wheat, Mustard, Gram	Sierozems, eastern part alluvial, west, north- west lithosols, foot hills, brown soils
7.	**IIIB-** Flood prone eastern plain	2.77	Alwar, Dholpur, Bharatpur, Karoli, Sawai Madhopur	500-700	Max. 40 Min. 8.2	Pearl millet, Clusterbean, Groundnut, Wheat, Barley, Mustard, Gram	Alluvial prone to water logging, nature of recently alluvial calcareous has been observed
8.	**IVA-** Sub-humid southern plains	3.36	Bhilwara, Sirohi, Udaipur, Chittorgarh	500-900	Max. 38 Min. 8.1	Maize, Pulses, Sorghum, Wheat, Gram	Soils are lithosols at foot hills & alluvials in plains
9.	**IVB-** Humid sothern plains	1.72	Dungarpur, Udaipur, Banswara, Chittorgarh	500-1100	Max. 39 Min. 7.2	Maize, Paddy, Sorghum, Blackgram, Wheat, Gram	Predominantly reddish medium texture, well drained calcareous, shallow on hills, deep soils in valleys
10.	**V-** Humid south eastern plain	2.70	Kota, Jhalawar, Bundi, Baran	650-1000	Max. 42 Min.10.6	Sorghum, Soyabean, Wheat, Mustard	Black of alluvial origin, clay loam, ground water salinity

Figure 2. Agro-climatic zones of Rajasthan
(Source- www.Krishi.Rajasthan.gov.in)

C. Interactive Workshop - IGFRI and State Department

One day online workshop on 'Fodder Resource Development Plan for Rajasthan' was organised on July 10, 2020 by ICAR-Indian Grassland and Fodder Research Institute (IGFRI), Jhansi in collaboration with Department of Animal Husbandry, Govt. of Rajasthan and Directorate of Agriculture, Govt. of Rajasthan. Meeting began with the welcome address by Dr. Vijay Kumar Yadav, Director, IGFRI, Dr. Yadav apprised to the auspicious gathering regarding importance of livestock production in livelihood of rural people especially in area of arid and semi-arid regions and future needs and scope of fodder resource development in Rajasthan. He also summarized about research accomplishments on fodder resource development, conservation and utilization at IGFRI and AICRP-FCU centres.

Dr. J.S. Sandhu, Hon'ble Vice Chancellor, SKNAU, Jobner in his inaugural address, appreciated the efforts made by IGFRI for organising the workshop on such an important subject like fodder resource development at the right time. Dr. Vishnu Sharma, Hon'ble Vice Chancellor, RAJUVAS, Bikaner in his inaugural address appreciated the efforts of IGFRI in this direction.

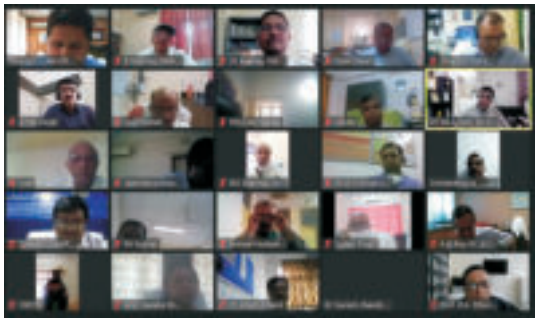

Figure 3. Interactive workshop

Dr. SS Meena, PS, IGFRI, Avikanagar presented agro-climatic zone-wise scenario of livestock production and fodder resources of the Rajasthan, SWOT analysis, plan for fodder resource development for the Rajasthan state. Dr. A.K. Roy, PC, AICRP-FCU presented list latest varieties and production technologies of various fodder crops developed and recommended for varied agro-climatic zones of Rajasthan. Dr. Sunil Kumar, Head, Division of Crop Production, IGFRI, presented fodder production technologies suitable for different agro-climatic conditions of Rajasthan. Dr. RV Kumar, Head, Division of Grassland & Silvipasture Management, IGFRI presented importance of round the year fodder production from non-arable lands. Dr Sunil Kumar PS (GSM), IGFRI presented hortipasture technologies suitable to state. Dr. Sultan Singh, PS, IGFRI presented fodder based rationing and conservation technologies.

Dr. Pradeep Saraswat, Additional Director (Farm & Estate), DAH, Govt. of Rajasthan, briefed about animal husbandry status of the state..

The workshop ends with formal vote of thanks to all the dignitaries and participants for attending the workshop and contributing valuable inputs by Dr. Purshottam Sharma.

D. Livestock scenario

India ranks first in milk production, accounting for about 20% of world production. Milk production in India has been increasing steadily over the years from 55.6 million tonnes in 1991-92 to 176.3 million tonnes in 2017-18, at an average annual growth rate of 4.5 percent. India is also the largest consumer of milk in the world. The integrated co-operative system of milk collection, transportation, processing, and distribution is responsible for the large-scale production of milk in the country.

Rajasthan is the second largest producer of milk in the country. In 2015-2016 the cattle milk production in Rajasthan was 18500 thousand tonnes which increased to 20850 thousand tonnes in 2016-2017. Around 75% of the population of Rajasthan lives in rural areas. Of these, nearly half of the population is involved in dairying or cattle-rearing which ultimately makes this state second highest milk producing state in the country. Animal Husbandry contributes about 10% in the GSDP of the State. This sector has a great potential for rural self-employment at lowest possible investment per unit. Therefore, livestock development is a critical pathway to rural prosperity.

As per the livestock census of 2012, there are 577.32 lakhs animals and over 80.24 lakhs poultry in the State. Rajasthan has about only 7% of the country's cattle population and contributes about 12.72% of the total milk production, 2.46% of the meat and 34.46% wool produced in the country. Rajasthan is first in wool production while second in milk production. Dairying is the most reliable source of earning to farmers in Rajasthan but with disappearing grazing land, restricted forest and stall feeding, the bovine are facing a severe shortage of fodder. The average density of livestock of Rajasthan is 169 per sq. kms. with range of 83 (Jaisalmer) to 292 (Dousa) as per census 2012.

Keeping this facts in mind extra efforts need to be made to formulate a fodder production plan based on the soil characteristics and climatic conditions of the state to enhance the green and dry fodder availability for livestock. The prominent range species of this region are *Cenchrus ciliaris, C. setigerus, Lasiurus scindicus, Dichanthium annulatum, Chrysopogon fulvus, Heteropogon contortus*, *Panicum antidotale* etc. The over-grazing has resulted in grassland deterioration and desertification. Therefore, rejuvenation/establishment of improved grasslands and systematic utilization of pasture lands would facilitate sustainability of livestock production in western region. Among the various reasons for poor condition of grasslands, one of the reasons is non availability of seed of range grasses as well as poor quality (low germination and higher empty seeds percentage) of seed which limits in establishment and maintenance of proper plant density of grasslands.

Table 3. Livestock population of Rajasthan 2019 (in millions)

State/Country	India	Rajasthan	State rank	% share of Rajasthan	% (+/-) over 12th Census
Cattle (Exotic/crossbred)	50.42	2.3		4.4	+0.56
Cattle (Indigenous)	142.11	11.6		7.7	0.0
Cattle (Total)	192.49	13.9	6	12.1	+0.6
Buffalo	109.85	13.7	2	11.9	+0.7
Sheep	74.26	7.9	4	14	-1.2
Goat	148.88	20.84	1	16	-0.9
Camel	2.5	2.37	1	80	-37.1
Total	535.78	56.49	2	11.4	-1.23

Source: Livestock census 2019

Table 4. Milk production of Rajasthan

Year	2014-15	2015-16	2016-17	2017-18	2018-19
Rajasthan	16934	18500	20850	22427	23668
India	146314	155491	165404	176347	187749
% of India in Rajasthan	11.6	11.9	12.6	12.7	12.6

Source: Livestock census 2012 and Agricultural data book 2018

Table 5: Rajasthan livestock population in 2012 and 2019

Species/Year	2012	2019	(+/-) %
Cattle -Crossbred	1.74	2.3	+0.56
Cattle - Indigenous	11.6	11.6	0
Total Cattle	13.3	13.9	+0.6
Buffalo	13	13.7	+0.7
Total Cattle & Buffalo	26.3	27.6	+1.3
Sheep	9.1	7.9	-1.2
Goat	21.7	20.8	-0.9
Horse/Pony	0.38	0.34	-0.04
Pig	0.24	0.15	-0.09
Total Livestock	57.72	56.49	-1.23

Source: Livestock census 2019

Table 6 : Milk Yield and Milk Production in Rajasthan state (2017-18)

Milk production status	Rajasthan	Reference
Per capita availability of milk (ml/day)	834	Basic Animal Husbandry
Total milk production ('000 MT)	22427	& Fisheries Statistics, 2018
Avg. milk yield per in-milk indigenous Cattle (kg/day)	4.89	(AHS series-19), GOI, Min. of Agri. & Far.
Avg. milk yield per in-milk crossbred cattle (kg/day)	2268.86	Wel., DAHDF, Pp17-37
Avg. milk yield in-milk Buffalo (kg/day)	6.61	

In spite of the large population of livestock in the state productivity remains very low. Some of the constraints for low productivity may be enumerated as i) absence of quality germ-plasm, as most of the animals are of non-descript breeds resulting in low productivity, ii) acute shortage of feeds and fodder, iii) high animal density, iv) small holding size limiting fodder cultivation, v) recurrence of flood and (vi) poor perception of the farmers towards livestock production as a viable alternative etc.

E. Fodder Scenario

The productivity of livestock is mainly dependent on green and dry fodder. The state possesses a shortage of green fodder and compounded feed to the extent of about 27.16 percent and 35.80 percent respectively. Cultivation of fodder crops are the cheapest source of feed for livestock but the area under fodder cultivation is meager. The declining area and deteriorating quality of natural grassland has further compounded the problem. Current requirement of green fodder in the state is 8.10 million tones, while the availability is only 5.90 million tones. Thus the availability of green fodder is hovering around 73.0 percent in this decade. If this supply is increased, the milk production in the state will also increase and the income of the farmers will also increase. The annual dry fodder requirement of Rajasthan state is estimated around 5.0 million tonnes of which, only about 3.21 million tonnes is available which is about 64 % of the actual requirement. Occurrence of drought and flood are regular feature in many districts of the state which is further aggravating the deficit of feed and fodder. Despite this feed constraint, milk production in the state has exihibited increasing trend because of more dependence on concentrates which is much more costly than green fodder.

Looking at the vast gap between the demand and supply, it becomes necessary to put adequate efforts to transfer the potential technologies developed by various research organizations of the state and country to farmer's field in order to increase the production and productivity of good quality fodder. Therefore, there is an urgent need of development of fodder security plan for round the year fodder supply in different agro-climatic zones of the state.

Table 7. Predominant fodder resources of arable land in Rajasthan

Fodder resources	Crops
Kharif crops	Pearl millet, Sorghum, Maize, Cowpea, Cluster bean, Moth bean, Velvet bean, Field bean and Moong, etc.
Rabi crops	Oat, Barley, Lucerne, Berseem, Maize, Senji, Mustard, Pea, Fenugreek, Kasani, etc.
Zaid crops	Pearl millet, Sorghum, Maize, Lucerne, Moong
Crop residues	Straw of Wheat, Barley, Oat, Pearl millet, Sorghum, Maize, pulses like Moong, Moth, Cowpea, Cluster bean, Groundnut, etc.
Trees/shrubs	Khejri, Bordi, Jal, Ardu, Ker, Vilayati babool, Acacia species, Neem, Gundi, Bui, Kheep, Dhav, Phog, etc.
Perennial crops	BN Hybrid, Tri-specific Hybrid (TSH), Guinea grass

Table 8: Estimated fodder demand-supply scenario (million tonnes)

Attributes	India	Rajasthan
Fodder demand		
Green fodder	850.9	8.10
Dry fodder	530.2	5.00
Fodder supply		
Green fodder	577.3	5.90
Dry fodder	471.9	3.21
Deficit (%)		
Green fodder	32.15	27.16
Dry fodder	10.99	35.80

(Note: For calculation of demand of dry and green forages, data were adopted from article India's livestock feed demand: Estimates and projections. Dikshit, AK and PS Birthal. 2010. Agricultural Economics Research Review, 23(1): 15-28)

SWOT analysis of fodder development in Rajasthan

Strength

- Rajasthan is the largest state of the country that has an area of 342,239 square km. (around 10.4 % of India) therefore large number of animals can be sustained and which can contribute in the rural economy.
- About 10% and 13% waste land and fallow land is available in the state which can be taken under fodder production through different fodder production systems.
- A sizable population is engaged in animal husbandry in the state for their livelihood through production of various livestock end products *viz*. milk, meat, wool etc.

- Availability of dual type and high fodder yielding varieties of fodder crops.
- All type of agro-climatic condition prevails in the state (humid, sub tropical, semi-arid and arid)
- Livestock sector is still main occupation of livelihood of rural people in the state.
- About 4% pasture land and grassland is available for grazing especially for small ruminants bovines.
- Large area is under pearl millet/sorghum and legume/pulses cultivation during monsoon under rainfed condition which is major and cheap sources of quality dry fodder production.

Opportunity

- With the rise in standard of living of human population, demand has increased for livestock products *viz* milk and meat which is driving force creating interest for livestock keeping as livelihood.
- In the state large area is under rainfed condition and there is meager use of chemicals and fertilizers that is favorable for organic livestock production for which demand is continuously increasing.
- Climate variability within the state can be used for production of different kind of fodder crops in the same season.
- Peri-urban dairy creating organized fodder market and need for post-harvest processing of fodder and crop residues and formulation of complete food.
- Large area is under wasteland which can be used for fodder production by adopting different fodder production systems.
- By optimum utilization of land resources, the deficit of fodder in the state can be substantially reduced.
- Introduction of innovative techniques of fodder production can increase availability of fodder to livestock in the drought prone areas.

Weakness

- Lack of adoption of improved package technology of fodder production, conservation and utilization.
- Lack of use of proper inputs and weed management practices in fodder crops.
- Land under fodder crops is static or even little reducing due to depletion of ground water and irrigation facilities.
- Lack of promotional schemes for production and marketing of quality seeds of forages.
- Uneven and unreliable rainy seasons and frequent occurrence of drought situation.

- Regional fodder imbalance and uneven fodder production and distribution.
- Conservation and storage of fodder is costly due to high volume.
- Unorganized marketing of fodder and transportation of bulky fodder is not cost effective due to high volume.

Threats

- Uncertainty in crop production due to recurrent drought and reducing rainfall and other weather vagaries.
- Continues depletion of ground water is biggest hurdle in cultivation of green fodder crops.
- Competition between commercial crops (eg grain, pulses, oilseed, vegetable production) and fodder crops.
- Reduction of fodder resources from forest area and waste lands due to decreasing rainfall, increasing pressure of stray animals and lack of seeding of grass/legume, bushes and trees.
- Over grazing of pastures, community grazing resources and over lopping of fodder trees and bushes.
- Improper composition of perennial grasses, range legumes, fodder bushes and trees in the prevailing grazing lands.
- Lack of proper protection measures of sown pasture/improved pasture and issues of benefit sharing of grassland area/produce with local communities.

Part-II : Fodder Resource Development Plan

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

Common property resources, including pastures, constitute an important component of livelihood assets of communities in semi-arid areas of Rajasthan and offer vital income and sustenance opportunities in the harsh agro-climatic conditions. Accordingly, Rajasthan has a long history of well designed management systems for pasture lands. These management systems have emerged in light of the key role that livestock plays in people's livelihoods and for the local economy.

Keeping in view the constraints in fodder production and in order to overcome the gap between demand and supply, a coordinated efforts needs to made for augmenting the fodder production. The high yielding and better nutritional varieties of fodder crops and fodder production models involving annual and perennial forages and balance between productivity functions and conservation practices needs to be promoted and popularized. It is suggested to grow forage grasses and fodder trees along village roads and panchayat lands.

Many traditional systems for collective management of pasture lands have existed in Rajasthan, where livestock rearing and transhumance have been an important part of people's livelihood strategies in the face of a harsh environment and highly variable climate. Use of participatory mode to identify the problems and to carry out the fodder production improvement programme on graziers, forage based agroforestry systems to maintain the productivity of pasture (grazing should be allowed as per carrying capacity) are some other solutions to this problem.

Strategies for enhancing fodder resources

A. Cultivated fodder resources

Crop production and animal husbandry go hand in hand for resource conservation and their utilization for sustainable agriculture in arid Rajasthan. Adverse climatic conditions like low and erratic rainfall, frequent droughts, high temperature, speedy winds, high evapo-transpiration and poor water resources are the major constraints for

crop production. Cattle, buffalo, sheep, goat and camel are indispensible and generate income and employment for livelihood support for rural families. Animal husbandry in arid Rajasthan is largely dependent on crop residues, rangelands/ pastures, fodder trees and shrubs. Presently, the grazing resources of arid Rajasthan are shrinking and their grazing capacity has also declined due to un-judicious utilization and high grazing pressure. Now, there is an urgent need to augment fodder production, planting high yielding fodder varieties and adopting improved crop management practices, pasture improvement adopting technological interventions and plantation of trees and shrubs to establish green fodder bank for sustainable livestock production. Approximately half of the total area of state is under cultivation with cropping intensity of 125 per cent. About 5% area is under pasture and grazing land. Since fodder cultivation is taken on very less area and due to this there is a very vast gap between demand and supply of green fodder. Hence it should be planned to bring at least 5% of the cultivated area under fodder crops.

There are large number of perennial grasses, range legumes, cultivated forage cereals & legumes grown in Rajasthan. The crops like bajra, sorghum, maize, cowpea, guar, oats, barley, lucerne/berseem etc are suitable for irrigated and arable land conditions whereas grasses like sevan grass, anjan grass, dhaman grass, marvel grass, *stylo santhesis hamata*, clitoria etc. are suitable for rainfed and non-arable land conditions. Crops like Bajra Napier hybrid, guinea grass, bajra tri-species hybrid etc. being perennial in nature, once planted will be able to provide fodder for 3-4 years and won't need frequent sowing and investment on seed cost and land preparation and also with the inclusion of leguminous fodder in inter row space of perennial grasses, they can supply round the year green fodder. In view of stiff competition with food & other commercial crops, forage varieties with tolerance in drought/water scarcity situations holds promise and can fit well in existing farming systems.

There are certain crops which are valued for grain as well as fodder and therefore categorized as dual purpose crops. In the present scenario of fragmented and small land holdings, breeding efforts are going on to develop high yielding varieties of dual purpose crops, so that farmer can get green fodder and food grain from the crops in the same season from the same piece of land. Pearl millet, sorghum and barley have excellent growth, biomass production has been recognized for dual purpose cultivation, where regenerated crop is managed for seed production after first fodder cut. The fodder crop improvement program of ICAR, along with State Agricultural Universities, has developed many potential varieties of fodder crops for different agroecological situations of arid and semi-arid regions.

Table 9. Zone wise suitable fodder crops and varieties

Zone/Fodder crops	Varieties	Seed rate/ha	Green fodder yield (t/ha/annum)
IA- Arid Western plains			
Pearl millet	AVKB-19, Raj Bajra Chari 2, PBN-342, AFB-3, PAC-981	6-8 kg/ha	15-20
Sorghum	PC-6, PC-9, MP Chari, CSH-24, COFS-29	20-30 kg/ha	25-35
Clusterbean	BG-1, BG-2, RGC-936, HG 2-20	20-25 kg/ha	15-20
Mothbean	RMO-40	15-20 kg/ha	10-15
Oat	JHO-822, JHO 99-2, JHO 2000-4	80-100 kg/ha	25-30
Lucerne	RL-88, Anand-2, RRB-07-1, AL-4	15-20 kg	70-90
Methi	HFM-65, T-8	20-25 kg/ha	10-15
IB- Irrigated North Western plains			
Sorghum	MP Chari, PC-6, PC-9, PC-23, CSH-24,	20-30 kg/ha	25-35
Pearl millet	Giant Bajra, AVKB-19, Raj Bajra Chari-2, PBN-342, AFB-3, PAC-981	6-8 kg/ha	20-25
Maize	African tall, Pratap makka chari-6, J-1006	40-50 kg/ha	35-40
Clusterbean	BG-1, BG-2, HG 2-20, HG 75, RGC-1031	30-35 kg/ha	15-20
Cowpea	Cowpea 88, EC-4216, BL-1, -2, UPC-9202,	30-35 kg/ha	15-20
Oat	JHO-822, JHO 2000-4, JHO-851, OL-125, UPO-212	80-100 kg/ha	25-30
Lucerne	RL-88, Anand-2, RRB-07-1, AL-4	15-20 kg	70-90
Barley	RD-2035, RD-2715, RD-2592, RD-2508, RD-2552	80-100 kg/ha	35-40
IC- Hyper arid partial irrigated Western plains			
Pearl millet	AVKB-19, Raj Bajra Chari-2, PBN-342, AFB-3, PAC-981	6-8 kg/ha	20-25
Clusterbean	BG-1, BG-2, HG 2-20, HG 75, RGC-1031	20-25 kg/ha	15-20
Mothbean	RMO-40	20-25 kg/ha	10-15
Oat	JHO-822, JHO 2000-4, JHO-851, OL-125, Kent, OS-6	80-100 kg/ha	30-35
Lucerne	RL-88, Anand-2, RRB-07-1, AL-4	15-20 kg	70-90
Barley	RD-2035, RD-2715, RD-2592, RD-2508, RD-2552	80-100 kg/ha	35-40
IIA- Transitional plain of Inland drainage			
Pearl millet	AVKB-19, Raj Bajra Chari-2, PBN-342, AFB-3, PAC-981	6-8 kg/ha	20-25
Sorghum	CSH-24, SSG-59-3, MP Chari, COFS-29, PC-6, PC-9	20-30 kg/ha	25-35

Clusterbean	BG-1, BG-2, HG 2-20, HG 75, RGC-1031	20-25 kg/ha	15-20
Mothbean	RMO-40	20-25 kg/ha	10-15
Oat	JHO-822, JHO-2000-4, JHO-851, OL-125, UPO-212,OS-6	80-100 kg/ha	35-40
Lucerne	RL-88, Anand-2, RRB-07-1, AL-4	15-20 kg	70-90
Barley	RD-2035, RD-2715, RD-2592, RD-2508, RD-2552	80-100 kg/ha	30-40
IIB- Transitional plain of Luni basin			
Pearl millet	AVKB-19, Raj Bajra Chari-2, PBN-342, AFB-3, PAC-981	6-8 kg/ha	15-20
Sorghum	CSH-24, SSG-59-3, MP Chari, COFS-29, PC-6, PC-9	20-30 kg/ha	25-35
Clusterbean	BG-1, BG-2, HG 2-20, HG 75, RGC-1031	20-25 kg/ha	15-20
Oat	JHO-822, JHO 2000-4, JHO-851, OL-125, Kent, OS-6	80-100 kg/ha	35-40
Lucerne	RL-88, Anand-2, RRB-07-1, AL-4	15-20 kg	70-90
Barley	RD-2035, RD-2715, RD-2592, RD-2508, RD-2552	80-100 kg/ha	35-40
IIIA- Semi arid Eastern plains			
Pearl millet	Giant Bajra, Raj Bajra Chari-2, AVKB-19, PBN-342, AFB-3, PAC-981	6-8 kg/ha	20-25
Sorghum	MP Chari, PC-9, PC-23, CSH-24, SSG-59-3, COFS-29, PC-6,	20-30 kg/ha	25-35
Clusterbean	BG-1, BG-2, HG 2-20, HG 75, RGC-1031	20-25 kg/ha	15-20
Cowpea	EC-4216, BL-1, BL-2	30-35 kg/ha	15-20
Oat	JHO-822, JHO 2000-4, JHO-851, OL-125, UPO-212	80-100 kg/ha	35-40
Lucerne	RL-88, Anand-2, RRB-07-1, AL-4	15-20 kg	70-90
Barley	RD-2035, RD-2715, RD-2592, RD-2508, RD-2552	80-100 kg/ha	35-40
Methi	HFM-65, T-8		
Mustard	Chinease Cabbage	5-7 kg/ha	20-22
IIIB- Flood prone Eastern plain			
Sorghum	MP Chari, PC-9, PC-23, CSH-24, SSG-59-3, COFS-29, PC-6, PC-9	20-30 kg/ha	25-35
Pearl millet	Giant Bajra, Raj Bajra Chari-2, AVKB-19, PBN-342, AFB-3, PAC-981	6-8 kg/ha	20-25
Maize	African tall, Pratap makka chari-6, J-1006	40-50 kg/ha	35-40
Clusterbean	BG-1, BG-2, HG 2-20, HG 75, RGC-1031	20-25 kg/ha	15-20
Cowpea	EC-4216, BL-1, BL-2	30-35 kg/ha	15-20
Oat	JHO 99-1, JHO-822	80-100 kg/ha	35-40

Lucerne	RL-88, Anand-2, Anand-3, RRB-07-1, AL-4	15-20 kg	70-90
Berseem	Bundel Berseem-2 & -3, BL-2, Wardan, JBSC-1	30-35 kg	60-70
Barley	RD-2035, RD-2715, RD-2592, RD-2508, RD-2552	80-100 kg/ha	35-40
Methi	HFM-65, T-8	15-20 kg	15-20
IVA-Sub-Humid Southern plains			
Sorghum	MP Chari, PC-9, PC-9, PC-23, CSH-24, COFS-29	20-30 kg/ha	35-40
Maize	African tall, Pratap makka chari-6, J-1006, CO HM - 8	40-50 kg/ha	30-35
Cowpea	EC-4216, BL-1, BL-2, UPC-9202	30-35 kg/ha	15-20
Oat	JHO 99-1, JHO-822, Kent	80-100 kg/ha	35-40
Barley	RD-2035, RD-2715, RD-2592, RD-2508, RD-2552	80-100 kg/ha	35-40
Lucerne	RL-88, Anand-2, Anand-3	15-20 kg	70-90
IVB- Humid Southern plains			
Sorghum	MP Chari, PC-6, PC-9, PC-23, CSH-24, SSG-59-3, COFS-29	20-30 kg/ha	35-40
Maize	African tall, Pratap makka chari-6, J-1006	40-50 kg/ha	35-40
Pearl millet	Raj Bajra Chari-2, AVKB-19	6-8 kg/ha	35-40
Cowpea	EC-4216, BL-1, BL-2, UPC-9202	30-35 kg/ha	20-25
Oat	JHO 99-1, JHO-822	80-100 kg/ha	35-40
Lucerne	RL-88, Anand-2, RRB-07-1, AL-4	15-20 kg	70-90
Berseem	BL-2, Bundel Berseem-2, -3, JBSC-1	30-35 kg	60-70
Barley	RD-2035, RD-2715, RD-2592, RD-2508, RD-2552	80-100 kg/ha	35-40
V- Humid South eastern plains			
Sorghum	MP Chari, PC-6, PC-9, PC-23, CSH-24, SSG-59-3, COFS-29	20-30 kg/ha	25-35
Maize	African tall, Pratap makka chari-6, J-1006	40-50 kg/ha	35-40
Pearl millet	Raj Bajra Chari-2, AVKB-19	6-8 kg/ha	20-25
Cowpea	EC-4216, BL-1, BL-2, UPC-9202	15-20 kg	15-20
Oat	JHO 99-1, JHO-822	80-100 kg/ha	35-40
Lucerne	RL-88, Anand-2	15-20 kg	70-90
Berseem	BL-2, Bundel Berseem-2, -3,Wardan, Mescavi, JBSC-1	30-35 kg	60-70
Barley	RD-2035, RD-2715, RD-2592, RD-2508, RD-2552	80-100 kg/ha	35-40
Methi	HFM-65, T-8	15-20 kg	20-25

Perennial fodder crops	
Bajra Napier	BNH-10, TNCN-074, TNCN-1280, BNH-14, HybridBNH-11
Guinea grass	JHGG 08-1, TNGG-062, RSDGG-1

Round the year fodder production system:

Intensive forage production systems are tailored with an objective of achieving high yield of green nutritious forage and maintaining soil fertility. Suitable cropping system that comprises of raising dual purpose varieties, inter-planted with Bajra Napier hybrid/guinea grass. The fodder can also be knitted in existing food grain/commercial production systems as these are equally or more remunerative. The detailed list of fodder based crop sequences is given below.

Table 10. Annual green fodder production of different crop sequences

Fodder cropping sequence	Green fodder production (t/ha)
Multi-cut pearl millet + cowpea - oat + mustard/barley + mustard	120-140
Multi-cut sorghum - oat + mustard/barley + mustard	110-130
Maize + cowpea - lucerne	90-100
Maize + cowpea - methi - maize + cowpea	70-100
Maize + cowpea - oat + mustard/barley + mustard - maize + cowpea	90-110
Single-cut pearl millet + cowpea/single-cut sorghum + cowpea - oat + mustard/barley + mustard - maize + cowpea	110-130

B. Fodder production through horti-pasture and silvi-pasture system

There are various alternate land use (ALU) systems which may provide fodder such as silvi-pasture, horti-pasture and agri-horti-silvipasture. Many multipurpose tree species (MPTS)/shrubs growing in ALU systems are useful as leaf fodder used for animal feed besides wood. These activities contribute significantly to domestic livestock production, which in turn influences milk and meat supply and contributes to household income and also provide shelter to the animals during hot summer days. In Rajasthan, leaves of tress species grown in agroforestry are being used as leaf fodder mostly for sheep and goat during lean period. There is ample scope and many opportunities for introducing fodder crops in existing orchards. Horti-pasture system integrates pasture (grass and /or legumes) and fruit trees to fulfil the gap between demand and supply of fruit, fodder and fuel wood through utilizing moderately degraded land (Table 11). Ber, aonla, guava, beal, sahajan, sahatoot etc. based hortipasture systems have been experienced for enhancing forage productivity at IGFRI.

Table 11. Zone wise suitable horti-pasture, silvi-pasture and range grasses

Zone	Horti pasture	Silvi pasture	Range grasses
IA- Arid Western plains	Ber/Lasoda + Sewan/ Anjan/Dhaman grass	Khejri/ Ardu + Sewan/Anjan/ Dhaman grass	Sewan, Anjan, Dhaman grass
IB- Irrigated North Western plains	Ber+Anjan/Dhaman+ *Stylo hamata* Kinnow + Guinea grass	Ardu/ Khejri+ Anjan/Dhaman, Anjan grass, Dhaman	Subabul+Anjan/ Dhaman grass
IC- Hyper arid partial irrigated Western plains	Ber+Anjan/ Sewan grass; Ber/Lasoda+ Dhaman/ Sewan, Aonla + Anjan/ Sewan	Babul/ Khejri/ Ardu + Anjan/ Dhaman/ Sewan	Sewan grass Anjan grass Dhaman grass
IIA- Transitional plain of Inland drainage	Ber/Lasoda + Anjan/ Dhaman, Aonla + Dhaman/Anjan grass	Acacia/ Khejri + Dhaman/ Anjan grass	Anjan, Dhaman, Lampa, Blue panic grasses
IIB- Transitional plain of Luni basin	Ber/Lasoda + Dhaman/ Anjan grass + *Stylo hamata*, Aonla + Anjan + *Stylo hamata* Pomegranate+Dhaman+ Stylo. hamata	Acacia/ Khejri + Anjan grass Khejri+ Dhaman grass	Anjan, Dhaman Lampa, Marvel grasses
IIIA- Semi arid Eastern plains	Ber+Anjan/Dhaman+ *Stylo Hamata*, Aonla + Guinea grass	Neem/Ardu + Anjan/Dhaman *Hardvikia binata* + Anjan/Dhaman	Dhaman, Anjan Marvel grasses
IIIB- Flood prone Eastern plain	Ber + Anjan grass + *Stylo Hamata*, Aonla + Guinea grass, Citrus/Guava + NB Hybrid	Acacia/Khejri + Anjan, Subabool + Dhamn grass, Neem/Ardu/ *Hardvikia binata* + Dhaman grass	Dhaman, Anjan, Lampa, Clitoria, Marvel grass, Sehima, Guinea grasses
IVA-Sub-Humid Southern plains	Aonla + Guinea grass (BG-1)/ BN Hybrid, Guava + BN Hybrid + *Stylo hamata*	*Leucena Leucocephala*+ *Cenchrus setigerus,* Neem/Ardu + *C. setigerus*	Dhaman, Anjan Clitoria, Marvel, *Sehima nervosum,* Guinea grass
IVB- Humid Southern plains	Mango + Guinea grass/ NB Hybrid, Aonla+ Guinea grass/ NB Hybrid, Guava + BN Hybrid+ *Stylo hamata*	Subabool + Marvel grass/Guinea grass, Neem/Ardu + Anjan, *H. binata* + Dhaman	Marvel grass, Sehima, Guinea grass, Dhaman, Anjan grass, *Stylo. sebrana*
V- Humid South eastern plains	Citrus + NB Hybrid/ Guinea grass + Stylo, Guava + BN Hybrid/ Guinea grass+hamata	Subabool + Marvel grass/Rhodes/ Guinea grass, Moringa/Sesbania/ Desmanthus + Marvel grass/Rhodes grass/ Guinea grass	Marvel, Dhaman, Anjan, Guinea, Sehima grasses, *Stylosanthus sebrana*

Figure 4. Ardu based Silvi-pasture system

Figure 5. Neem based Silvi-pasture system

Figure 6. Guava based Horti-pasture system

Figure 7. Aonla based Horti-pasture system

C. Fodder from permanent pasture land/grazing lands

Community pastures are an important resource of fodder in the arid and semi-arid area of Rajasthan. Village common lands contribution to fodder, income, employment opportunities, resource conservation and improvement in micro-climate and environment etc. is appreciable. Below poverty line population is dependent on the CPRs. Meanwhile, changing rainfall patterns in the state have led to a shift from agriculture to animal husbandry. Livestock constitutes a major source of livelihood for the poor, but is constantly under threat due to shortage of fodder and potable water due to groundwater depletion. Many pastureland development projects has involved the community in revitalising common pastures, solving the problem of fodder, regenerating wastelands and boosting soil and water conservation.

Dichanthium-Cenchrus-Lasiurus pasture cover is predominant perennial grass component of Rajasthan. These grasses are well adapted to semi-arid to sub-humid regions with annual rainfall 300-900 mm and can grow on wide range of soils and environments due to its drought and temperature tolerance. It gives 8-10 t/ha dry fodder during monsoon season under rainfed condition. It is highly palatable with high nutrition value (crude protein 8-10% with 60-70% digestibility) for all kinds of grazing

animals. It is suitable for grazing, cut and carry, making silage and as hay. Most of the grazing lands are underused due to lack of availability of quality seed of improved genotypes. There is wide gap between demand and supply of grass seed which resulted majority of grazing lands and wastelands of the country underutilized, therefore, rejuvenation/establishment of improved grasslands with suitable species and genotypes and systematic utilization of pasturelands would facilitate sustainability of livestock production. The predominant species along with improved varieties for the grassland development is given Table 12 and 13).

Table 12. Suitable range grasses and legumes for Rajasthan

Grasses	Rainfall (mm)	Soil type	Seed rate (kg/ha)	DFY (t/ha)
Sewan (*Lasiurus scindicus*)	250	Light	3-5	3.5
Anjan (*Cenchrus ciliaris*)	300	Versatile	5-6	4.0
Dhaman (*Cenchrus setigerus*)	350	Versatile	8-10	3.0
Blue panic (*Panicum antidotale*)	500	Versatile	2-4	3.0
Marvel grass (*Dichanthium annulatum*)	575	Medium to heavy	4-5	2.5
Guria grass (*Sehima nervosum*)	500	Mixed Red/black	7-8	2.5
Dinanath (*Pennisetum pedicellatum*)	400	Versatile	8-9	3.0
Rhodes (*Chloris gavana*)	600	Sodic	8-10	2.5
Bahia (*Paspalum notatum*)	550	Light	11-17	3.5
Sabi grass (*Urochloa mosmabicellatum*)	550	Versatile	2-4	3.0
Range legume species				
Stylo (*Stylosanthes scabra*)	450	Light to medium	5-7	3.5
Stylo (*Stylosanthes hamata*)	325	Light to medium	4-6	2.5
Siratro (*Macroptillium atropurpureum*)	500	Light to medium	7-8	1.8
Butter fly pea (*Clitoria ternatea*)	300	Light to medium	15-20	3.0
Bankulthi (*Atylosia scarabaeoides*)	300	Medium	10-12	2.0

Table 13. Prominent varieties of range grasses for enhancing fodder production

Species	Strains/varieties
Lasiurus scindicus	CAZRI-317, CAZRI-319, CAZRI-351, CAZRI-295, M 30-7, RLSB-11-50
Panicum antidotale	CAZRI-331, CAZRI-379, CAZRI-347, CAZRI-333
Cenchrus ciliaris	Marwar Anjan-75, IGFRI-3108, IGFRI-727, RCC-10-6, Bundel Anjan-4
Cenchrus setigerus	Marwar Dhaman (CAZRI-76); Pusa Yellow Anjan, Bundel Dhaman-1 (IGFRI-96-706)

Chrysopogon fulvus	IGFRI-1
Dichanthium annulatum	CAZRI-490, CAZRI-485, IGFRI-495-1, Marvel-8, JHD-2013-2
Clitoria ternatea	JGCT-2013-3
Hedge Lucerne	TND 1308

Figure 8. Sowing of grasses and plantation on CPRs

Figure 9. Improved grassland of *Cenchrus* on CPRs

Figure 10. Utilization of green fodder from grassland

Figure 11. Utilization of dry fodder from grassland

Figure 12. Seed production of *Cenchrus* grass

Figure 13. Safe storage of surplus fodder

Trees/shrubs as a source of fodder

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

Table 14. Prominent fodder trees and shrubs for sustainable fodder production

Tree/shrub	Suitable rainfall zone (mm)	Optimum plant geometry (m)	Green fodder yield/plant and availability after plantation
Khejri (*Prosopis cineraria*)	250-500	10 x 10	About 100 kg, 8-10 years
Anjan (*Hardwickia binata*)	400-750	10 x 10	20-25 kg, 7-8 years
Mopane (*Colophospermum mopane*)	250-500	8 x 8	5-7 kg, 3-4 years
Neem (*Azadirachta indica*)	350-1000	10 x 10	100-150 kg, 6-7 years
Ardu (*Ailanthus excelsa*)	400-800	10 x 10	100-150 kg, 5-6 years
Nutan (*Dichrostachys nutans*)	250-450	1.0 x 5.0	8-10 kg leaves and 2-3 kg pods plant-1 , 4-5 years
Subabool (*Leucaena leucocephala*)	350-1000	1.0 x 5.0	20-25, 2-3 years
Israili Babool (*Acacia tortilis*)	150-500	8 x 8	20-30 kg, 5-7 years
Deshi Babool (*Acacia nilotica*)	350-1000	10 x 10	50-60 kg, 5-7 years
Khajuri Babool (*Acacia nilotica*)	400-1000	6 x 6	20-25 kg, 5-7 years
Kumat (*Acacia senegal*)	250-750	8 x 8	8-10 kg, 7-8 years
Dhav (*Anogessus latifolia*)	400-750	10 x 10	8-10 kg, 7-8 years
Siris (*Albizia lebbeck*)	400-1000	12 x 12	20-30 kg, 5-7 years
Zhar beri (*Zizyphus nummularia*)	150-400	5 x 5	3-5 kg, 3-4 years
Khara Jal (*Salvadora persica*)	400-700	15 x 15	100-120 kg, 8-10 years
Meetha Jal (*Salvadora oleoides*)	350-600	12 x 12	80-100 kg, 8-10 years
Gundi (*Cordia gharaf syn. C. rothii*)	300-500	8 x 8	5-8 kg, 3-4 years

D. Fodder on non-competitive lands

Perennial grasses like anjan grass, guinea grass etc., can also be promoted in other niches like farm pond embankments, bunds, uncultivated farm lands, in orchards, rain

water outlets etc., to meet the green fodder at farm level. Introducing perennial cultivated grasses on farm bunds along with irrigation channels involves growing of 2 rows of Bajra Napier hybrid / guinea grass along with field boundary can supply 7-11 q green fodder per 100 m length of boundary per year which can support milch animal of livestock keepers without any additional expenditure Total number of farm families in Rajasthan is 68.88 lakhs with an average size of 3.07 ha which gives an opportunity to grow fodder on their bunds/boundary. Table 15 indicates the fodder production potential of bunds in the state.

Table-15 : Fodder production potential under different size of land holdings in Rajasthan

Size of holding	Total holding number	Average size of holding (ha)	Total bund length per holding (m)	Per holding available bunds length for use (m)	Potential of green fodder production per holding (q)		Green fodder production (,000 t)*	
					@7kg GF/m	@11kg GF/m	@7kg GF/m	@11kg GF/m
Marginal (<1 ha)	2511512	0.49	281	140	9.8	15.4	247	388
Small (1-2 ha)	1511068	1.43	478	239	16.7	26.3	253	398
Medium (2-4 ha)	1335144	2.83	673	336	23.5	37.0	314	494
Medium (4-10 ha)	1127122	6.14	991	496	34.7	54.5	391	614
Large (>10 ha)	403590	17.45	1671	836	58.5	91.9	236	371
All classes	6888436	3.07	701	350	24.5	38.5	1441	2265

Source: *State of Indian Agriculture, GoI.* * If only 10 % holdings kept under fodder under bund technology

E. Alternative fodder resources

There is a need for exploring the alternative or non-conventional fodder resources *viz.*, moringa, azolla, hydroponics, crushed areca nut leaves, pineapple wastes etc. Although azolla and hydroponics could be ideal sources of fodder and occupy lesser land area, they are labour intensive activities. These could be the better options when house-hold labour is involved in augmenting the fodder resources and those livestock keepers, who have lesser number of animals. However, these can be supplementary in nature and cannot substitute natural fodder production.

a. Moringa source of quality protein

Moringa is a good alternative for substituting commercial rations for livestock. The relative ease with which moringa can be propagated through both sexual and asexual means, it demands lesser soil nutrients and water, and easy to produce. Its high nutritional fodder resource quality and better biomass production, especially in dry periods. Moringa planted at ICAR-IGFRI, Jhansi at 50x50 cm spacing gave 80-130 tonnes green forage/ha in 4 cuts at 45 days harvest intervals in 2nd year of planting. Moringa leaves contain 21.53% crude protein, 24.07% acid detergent fiber and 17.55% neutral detergent fiber. One of its main attribute is its versatility, because it can be

Figure 14. Moringa based Silvi-pasture system

Figure 15. Sole plantation of Moringa

grown as crop or tree, fences in alley cropping systems, in agroforestry systems and even on marginal lands with high temperatures and low water availabilities.

b. Azolla as alternate fodder

In sub humid areas of state Azolla farming can be taken to supply protein supplement and reduce the cost on concentrate, Azolla farming in general, is inexpensive and it can be multiplied in natural water bodies for production of biomass. Biomass productivity is dependent on time and relative growth rate and efficiency of the species. Azolla is very rich in proteins, essential amino acids, vitamins (vitamin A, vitamin B12, Beta Carotene), and minerals including calcium, phosphorous, potassium, ferrous, copper, magnesium. On a dry weight basis, azolla has 25-35% protein, 10-15% mineral content, and 7-10% comprising a combination of amino acids, bio-active substances and biopolymers. During lean/drought period it provides sufficient quantity of nutrients and acts as a feed resource. Azolla is a highly productive plant. It doubles its biomass in 3–10 days, depending on conditions and it can yield upto 37.8 t fresh weight/ha (2.78 t DM/ha dry weight).

c. Sugar beet/fodder beet

Fodder beet is an important energy supplements for small and large both category of animal. Fodder beets contain about 16-22% dry matter and provide about 4000 kcal/ kg (dry matter) gross energy and digestibility in ruminants is about 85%. The crude protein content ranges between 7-8% on dry matter basis. Fodder beet can be cultivated in most of the parts of the state except high hills and in duration 140-150 days.

d. Cactus as an alternate fodder

Cactus commonly known prickly pear, could be an alternate fodder crop under moisture stress environment and resource poor farmers of Rajasthan. The cactus can be grown as an intercrop under wider row crops. This crop can grow under degraded soils, which are not suitable for other crops. The crude protein content is about 5 to 10%, cattle and goat can feed 50 to 70 kg and 6 to 8 kg of fresh cladodes per day.

F. Crop residue quality enhancement

The wheat, paddy, sorghum, bajra, maize, chickpea, urd, sugarcane, potato, etc are important crops of the Rajasthan state in which wheat and paddy straw and stover of millets are major source of dry fodder in the state. The paddy straw is low in protein content, low in palatability, digestibility and incapable to support even maintenance requirement of the adult ruminants, if fed as such. Urea treatment offers an opportunity to transform crop residues of poor quality into a valuable feed resource by refining it for rapid adoption at farmer's level for greater economic reward. Urea treatment of straw increases its N content resulting into enhanced microbial activity and ruminal digestion of the straw. In addition, urea treatment also exerts its effect on lingo-cellulose complex, wherein the lignin forms the complex with cellulose, thus preventing its microbial digestion. Urea also acts as preservative and application of urea solution on the straw and subsequent storage of treated straw would ensure the proper unspoiled storage. The use of a cheap source of nitrogen such as urea to improve the nitrogen content of such roughages makes a promising alternative to improve the nutritive value of straw. Further spray of salt and mineral mixtures will also enhance the palatability and nutritive value of dry fodders.

Figure 16. Mechanized urea treatment of crop residues during threshing

Figure 17. Wheat straw bells for better transportation and storage

G. Fodder conservation technologies – Hay, bales, silage, feed block

In recent times due to frequent droughts, failure of crops and non-availability of fodder has forced everybody into thinking of fodder conservation. Traditionally fodder conservation has been only with the dry fodder in the form of hay making and heaping. However, the lack of scientific hay making has often limited keeping quality of hay making and heaping. Recently there is greater emphasis on conserving green fodder popularly known as "Silage". While the hay making is possible with the dry fodders, green fodders are required for Silage making.

a. Hay/Bales:

Although it is common practice, necessary training is needed to ensure long keeping quality of the hay material. Further the dry fodder being voluminous in nature often

needs larger space and pose problems in transportation. Hence pressing dry fodder in bales to reduce keeping space and ease transportation has been found to be more necessary in recent times. The basic principle of hay making is to reduce the moisture content in the green forages sufficiently as to permit their storage without spoilage or further nutrient losses. The moisture content in hay must be less than 15% at storage time. Hence, crops with thin stems and many leaves are better suited for hay making as they dry faster than those having thick and pithy stems and small leaves.

b. Silage:

The basic principle of silage making is to convert the sugars in the ensiled fodder into lactic acid; this reduces the pH of the silage to about 4.0 or lower, depending on the type of process. However, its success will depend on surplus forage production, unreliable rainfall pattern, requirement for labour (cutting, raking, collecting, chopping, pit construction and cleaning, ensiling) and materials (polythene, molasses). Several green crops and grasses may be used for silage making *viz*. maize, sorghum, BNH grass, guinea grass, Cenchrus grass, sugarcane tops etc.

Figure 18. Silage preparation in plastic bags

Figure 19. Stack of the silage

c. Feed Block:

Bale making or feed block making could be good strategies for reducing the cost involved in transportation of fodder from one place to another and saving the space for keeping the fodder. The mechanization aspect may also be thought of in terms of harvesting with weed cutters and chaffing of fodder with power operated chaff cutters, which reduce the reliance on manual labour and also help in saving time on these activities. It will also help in supplying fodder during the calamities as well as lean season.

H. Custom Hiring Center

These need to be developed to provide equipments, machinery etc. to the farmers at affordable cost. Use of new machineries and technologies will enhance production, reduce drudgery and cost. The custom hiring centre should have all important implements/machinery required for fodder production (Table 16).

Table 16. List of equipment's, machinery for custom hiring centre

Prime Movers or General Machines	Land preparation/ Tillage machine	Sowing/ Transplanting machine/ Intercultural machines	Harvesting Machines
Prime movers (i) Tractor 2WD (above 20-40 PTO HP) (ii) Tractor 4WD (above 20-40 PTO HP) (iii) Tractor 2WD (above 40-70 PTO HP) (iv) Tractor 4WD (above 40-70 PTO HP) **General machines** (i) Post hole digger (ii) Tractor operated laser guided land leveler	(i) Disc plow (ii) Cultivator (iii) Disc harrow (iv) Leveler blade (v) Cage wheel (vi) Furrow opener (vii) Ridger (viii) Weed slasher (ix) Bund former (x) Crust breaker (xi) Roto-puddler (xii) Roto-cultivator	(i) Zero till seed cum fertilizer drill (ii) Potato Planter (iii) Multi crop planter (5tines) (iv) Ridge furrow planter (v) Pneumatic planter (vi) Self-propelled rice transplanter (8-12 rows) (vii) Pneumatic vegetable transplanter (viii) Plastic mulch laying machine (ix) Raised bed planter with inclined plate planter and shaper attachment (5-7 tines) (x) Grass Weed Slasher (xi) Power Weeder	(i) Tractor drawn crop reaper/ reaper cum binder (ii) Crop reaper cum binder (4 wheel) (iii) Power weeder (engine operated below 2 bhp) (iv) Power weeder (engine operated above 2 bhp) (v) Power weeder (engine operated above 5 bhp) (vi) Power operated horticulture tools for pruning budding, grating, shearing etc. (vii) Groundnut digger shaker (vii) Groundnut thresher (ix) Multi crop thresher (for wheat and paddy) (x) Combined harvester

Table 17. Identified suitable fodder interventions or technologies

Intervention	Aim
For green fodder production	
i. Introducing improved fodder crops in existing cropping systems or food fodder systems	Growing new high yielding fodder crops and their varieties to increase green fodder availability
ii. Introducing improved fodder crops in orchards and plantations	Use of non competitive land to increase green fodder availability
iii. Re-vegetation of pasture grasses on common grazing land	Enhancing grazing resources and fodder production
iv. Perennial forages on bunds and along with irrigation channels	Increase fodder availability and stabilise bund

v. Fodder shrubs and trees	Increase green fodder availability in summer and leaf meal preparation
For dry fodder use	
i. Improved chaff cutters (smaller, women friendly model)	Overcome problems faced by women in operating the mechanised wheeled model
Use of feed troughs	Reduce feed wastage during feeding
Fodder conservation	
i. Fodder baling and establishing fodder banks in dry matter surplus districts	To address fodder shortage in drought years
ii. Awareness and training on use of area specific mineral mixture	Encourage feeding area specific mineral mixture to improve efficiency of feed utilization

Details of fodder interventions

1. Introducing improved fodder crops in orchards and plantation helps to use inter-row spaces of fruit and plantation crops which otherwise left unutilised. Rajasthan has large area under ber, guava, aonla, citrus, orange and other orchard crops which can be put to use for cultivation of perennial fodder crops.
2. Re-vegetation of pasture grasses on common grazing land improve the production capacity as well as quality of the forage. Combination of grasses like *Cenchrus* spp., *Lasiurus*, *Dichanthium*; legumes *Stylosanthes* spp.; and shrubs and trees: *Sesbania* spp., *Leuceana leucocephala*, etc best suited for rejuvenation as they survive any harsh condition besides providing green fodder for the livestock.
3. Growing of 2 rows of Bajra Napier hybrid / guinea grass along with field boundary can supply 7-11 q green fodder per 100 m length of boundary per year which can support milch animal of livestock keepers without any additional expenditure.
4. Sesbania spp., Glyricidia, Subabul are some of shrub and tree species which need to be promoted all along field boundary. They are the best and cheap protein sources in summer and drought years. Leaf meal prepared from trees and shrubs act as feed reserve.
5. Simple chaff cutters in the form of weighted knives and mounted scythe cutters are of low-cost and are simple to use by farm women. Promotion of simple chaff cutter needs to be done in rainfall scarcity zone of Rajasthan.
6. Studies have shown that use of troughs reduce wastage by 20-30%. Promotion of improved feed troughs brings many benefits specifically to farm women. They no longer had to spend time to rearrange fodder around the animals to prevent trampling and soiling, and less soiled fodder to clear out from the cattle sheds.
7. Fodder baling and establishing fodder banks in fodder surplus districts:

8. Minerals are required by dairy animals for their metabolic functions, growth, milk production, reproduction and health. Therefore, animal should be supplemented with adequate amount of good quality mineral mixture in their ration.

Crop production Technology:

- Intercropping of sorghum (sown with 100% recommended seed rate at 50 cm spaced rows) with guar using 100% recommended seed rate was found as best system.
- Variety GFB-1 (pearl millet) supplemented with 150% of RDN under one cutting at 50 DAS for green fodder and left for grain was found most productive and remunerative.
- Sowing of dual purpose oats on 15th November supplemented with 30:40:40 kg/ha N:P:K and 12.5 kg $ZnSO_4$/ha as basal dose followed by 30 kg N each at 30 and 60 DAS as top-dressing and foliar sprays of 0.5% $ZnSO_4$/ha in 300 liter water at 60 DAS proved most productive and profitable in terms of GFY (246.1 q/ha) and grain yield (20.29 q/ha) with B:C ratio (2.39). The crop should be harvested in second week of January for fodder and in second week of April for seed.
- Planting of Bajra Napier hybrid + lucerne perennial intercropping system is recommended
- It is recommended to sow combination of 20 kg lucerne +30 kg oats seed/ha at 30 cm distance rows. The technology produced up to 465 q green fodder, 54 q dry matter or 7.6 q quality green fodder (CP Content-16.5%).

Crop protection Technology:

- For the the management of leaf spot diseases of sorghum particularly Zonate spot, seed treatment with carbendazim@ 2 g/kg seed followed by two foliar sprays of propiconazole @ 0.1per cent is recommended.
- For lucerne seed production, spraying of mancozeb (2.5g/lit) and tebuconazole (0.5 ml/lit) alternately at 15 days interval enhanced >40 per cent seed yield over control.
- Seed treatment with NSP (50 g/kg) followed by foliar spray of NSKE (5%) at 15 days after each cut reduced the pest and disease incidence in Lucerne and increased the fodder and seed yield.
- Mixture of *L. lecani* @ 1X10^8 CFU/g (5 g/lit) + *M. anisopliae* @ 1X108 CFU/g (5 g/lit) or *L. lecani* @ 1X10^8 CFU/g (5 g/lit) alone as a foliar application is recommended for the control of aphids on lucerne and foliar application of *N. releyi* @ 1X10^8 CFU/g (5 g/lit) + *B. bassiana* @ 1X10^8 CFU/g (5 g/lit) or *N. releyi* @ 1X10^8 CFU/g (5 g/lit) for the control of lepidopteran pests (*S. litura* and *H. armigera*).
- For the management of *Spodopteralitura* in lucerne, foliar application of SNPV @ 1 ml/lit + *B. bassiana* @ 5 g/lit of water at 8 pm is recommended.

Part-III : Brief Action Plan

i. Identification of areas for propagating fodder crops

Bench mark survey on the micro-climatic conditions, cropping systems and introduction of fodder crops may be initiated for identifying the suitable fodder crops and their varieties and production potential *vis-à-vis* the farmers' acceptance and their satisfaction.

ii. Selection of villages in different agro-climatic zones based on livestock resources

Among ten agro-climatic zones of the state, one district from each agro-climatic zone can be selected. Bench mark survey may be initiated in 2 blocks in each of the selected districts which will fairly give an idea about the possible conditions for propagation of fodder crops under varied situations.

iii. Identifying fodder species/varieties suitable for different agro-climatic zones

An exercise was made during the workshop to elicit the opinion of the staff of the Dept. of Animal Husbandry and Veterinary Services, Govt. of Rajasthan. Suitable fodder crops and their varieties would be more suitable for different agro-climatic conditions prevailing in the state of Rajasthan and should outlined in the recommendations. The same may be used as guideline for identification of suitable fodder crops and varieties.

iv. Providing package of practices for fodder crops

There are already well established package of practices for different fodder crops under various agro-climatic conditions. The same will be adopted as package of practices *mutatis mutandis* for successful cultivation of fodder crops in the state.

v. Master trainers training at IGFRI/SAUs

The staff of Department of Animal Husbandry, Veterinary, Agriculture, Horticulture, Forestry etc. from the Govt. of Rajasthan having aptitude to work for augmenting fodder resources will be identified through their superiors in the first stage as master trainers and they will be offered intensive need based training programme at IGFRI, Jhansi/ SAUs. The number of participants, duration of the training programme and the topics of training programme will be finalized after discussion with the Head of the line department, Govt. of Rajasthan.

vi. Creating awareness among farmers/stakeholders for cultivation of forage crops

There are Krishi Vigyan Kendras (KVKs) operating in the each district of the state. They will be roped in to identify the needy farmers for training on fodder crops.

Other stake holders like milk co-operatives, non-governmental agencies (NGOs) and progressive farmers will also be made partners in the process of creating awareness about fodder production.

vii. Conduction of frontline demonstration and training

After bench mark survey and identification of suitable places for propagating awareness about the fodder crops, sufficient number of front line demonstrations in each of the selected tehsil will be conducted on the farmers' field to make them aware of the fodder production potential and motivate them to go for cultivation of fodder as per the needs. In addition tailor made training programmes will be organized through KVKs for the benefit of the interested farmers on the topics of their interest in fodder crop production, livestock production and dairying.

viii. Strengthening of forage seed production chain

As emerged out of the discussion during the workshop, the non-availability of quality seeds and planting material of suitable fodder crops is one of the major hindrances for the cultivation of fodder crops. Therefore, efforts will be made to estimate the quantum of various fodder crops' seeds and planting material well in advance and an institutional mechanism will be put in place to ensure the availability of different category of fodder seeds and planting material so that the non-availability does not become an issue for fodder cultivation.

ix. Adoption of holistic approach - fodder production, conservation and utilization

All efforts will be made to interlink the activities of fodder production, its conservation either in the form of silage (for green fodder) or hay (for dry fodder), and its scientific utilization will be ensured through creating awareness on all these aspects and ensuring the compliance by the master trainers, trained farmers and other stake holders in the process.

x. Conservation of forage resources to mitigate calamities and ease of transport

In many areas in spite of having a large chunk of crop wastes residue with fodder value, it cannot be used due to faulty agricultural practices or lack of machinery etc. Hence conservation of fodder resources wherever possible for future use during lean periods and at time of natural calamities like famine, high rainfall etc. will be highlighted. Further as fodder is bulky in nature accounting for huge expenditure in transportation, bale making of dry fodders, silage in polybags of convenient sizes for transportation will be promoted and popularized among the livestock holders.

xi. Networking through ICAR-DAHD-SAUs-Milk Federations

Any isolated efforts to augment fodder resources may not be sustainable in long

run owing to some unforeseen situations in future. And hence, networking of fodder producers, fodder entrepreneurs, heads of line departments will be made for foreseeing at the grass root level. Likewise, networking of ICAR Institutions *viz*. IGFRI, NIANP, NDRI, IVRI, IIVR, IIPR, IISR, etc., Department of Animal Husbandry and Veterinary Services of the State and Central Government, Milk Federations and Dairy owners etc., will be established to supervise and evolve a mechanism to attend to problems associated with technologies and forth coming issues in future.

xii. Public-Private-Partnership (PPP) mode of operation

Although the initial stage of programme is hovering around the government agencies involved in various aspects of fodder production, processing, conservation, utilization, rationing, policy making, etc. the ultimate end user will be common farmers. Further there are several private players *viz*. dairy owners, animal pharma industries, feed manufactures, NGOs involved in livestock production and dairying etc. They will all be brought together under Public-Private Partnership (PPP) mode in more transparent, efficient and economical way for all the partners.

Part-IV : Road Map

This project is conceived to be multi-task, multi-partner and multi-location activity. Hence a proper road map is necessary for making it more practical and result oriented one. The following road map has been proposed under this project. There are several actions points to be carried out in the process of implementation by several agencies (Table 18).

Table 18: Road map for the implementation of the proposed activities

S.No.	Action point	Agencies involved
1	Breeder seed production of the identified varieties	IGFRI, Jhansi/SAUs
2	Foundation seed production	RFS/DAHD/SAHD
3	Production of TFL/certified seeds	SAUs/Milk unions/ NSC/SSC
4	Demonstration, Training of farmers, Field trials at farmers field, package of practices	District KVK/milk unions/SAHD
5	Extension activities and development of fodder warehouse	Milk Unions/State Animal Husbandry Department
6	Dry fodder processing, value addition and fodder management (chaff cutter, Fodder block, Baling, grinding)	District level milk union/Animal Husbandry Dept.
7	R & D activity (Evaluation of fodder quality, food-feed crops, Hydroponics etc.,)	ICAR Institutes/ SAUs/SVUs
8	Capacity building of stake holders	ICAR-IGFRI/SAUs

The programme implementation plan is a time bound multi-stage oriented and aims to complete the activities in time frame in a logical way.

Part-V : Implementation of Pilot Programme

Pilot project is proposed to be implemented in the selected areas to assess the acceptability, impact, refinement and methodology of technologies, if required. Pilot project is proposed to be implemented in selected villages. The detailed plan for implementation of pilot project is presented in the Table 19.

Table 19. Agro-climatic zone wise identified district for implementation of pilot project

S.No.	Agro-climatic zone	Identified district
1.	IA- Arid Western plains	Jodhpur
2.	IB- Irrigated North Western plains	Hanumangarh
3.	IC- Hyper arid Partial irrigated Western plains	Bikaner
4.	IIA- Transitional plain of Inland drainage	Sikar
5.	IIB- Transitional plain of Luni basin	Jalore
6.	IIIA- Semi arid Eastern plains	Tonk
7.	IIIB- Flood prone Eastern plain	Alwar
8.	IVA-Sub-Humid Southern plains	Bhilwara
9.	IVB- Humid Southern plains	Chittorgarh
10.	V- Humid South eastern plains	Bundi

Table 20. Implementation level plan for pilot project

S.No.	Activity	Action points
1	Target area selection	• Selection of 10 districts (1 from each agroclimatic zone) of Rajasthan • Selection of 2 cluster of 5 villages in each district total 20 clusters for 10 districts • Selection of 1 to 2 ha in each cluster for technology demonstrations • Bench mark survey
2	Training	• Training of master trainers- 25 master trainers per batch and 1 batch from each district at IGFRI, Jhansi • Training of farmers; 10 from each village; 1000 farmers in first year • Exposure visit of progressive farmers and master trainers at IGFRI, Jhansi and other ICAR institutes located in Rajasthan and nearby states/NDDB, Anand.

3	Technology Demonstrations	• Selection of crop and varieties will be done after identifying suitable districts and village clusters both under annual and perennial crops for different seasons *viz. kharif, rabi* and *zaid.* • Silage should be encouraged • Since crop residue being a precious commodity, fodder banks using densification technologies can be developed
4	Suitable silvi-pasture/ horti-pasture system demonstrations	• In existing orchard- 1 ha (guinea grass, grazing guinea) • In new orchard - 1 ha (guinea grass, grazing guinea) • Popular and potential fodder trees • Moringa can be a potential source of legume fodder in upland areas and may be explored
5	Micro irrigation facility development	• The related activities will be taken up during post rainy season/ with first rabi rains
6	Rejuvenation of grasslands on CPRs	• Suitable grass species *viz.* Anjan grass, dhaman grass, sewan grass, marvel grass, etc. to rejuvenate pasture & grazing lands and enhance fodder availability, check soil and water erosion and enhancing water retention.
7	Input supply	• Inputs *viz.* seeds/rooted slips/, fertilizers, insecticides etc, small machinery and tools - improved sickles etc. will be supplied to farmers

Financial Arrangements

Govt. of Rajasthan and Govt. of India through various state and central schemes like RKVY etc. can meet the fund requirement. ICAR-IGFRI will provide technical support for formulation of such fodder development proposals for funding. The fund requirement for the implementation of pilot project is computed and given in following Table 21.

Table 21. Approximate budget requirement for the implementation of pilot progamme

Sl. No.	Activity	Amount (Rs. In Lakhs)					
		Ist yr	IInd yr	IIIrd yr	IVth yr	Vth yr	Total
1	Training (Master trainer/ farmers/ stakeholders)	15.0	15.0	15.0	10.0	10.0	65.0
2	Exposure visit of farmers/ stakeholders	10.0	10.0	10.0	5.0	5.0	40.0
3	Seed/ planting material	15.0	15.0	5.0	5.0	5.0	45.0
4	Micro irrigation facilities	20.0	20.0	15.5	15.0	5.0	75.5
5	Other farm inputs, small equipments etc	15.0	15.0	10.0	5.0	5.0	50.0
6	Re-vegetation of pasture grasses on common grazing lands	20.0	20.0	10.0	10.0	5.0	65.0
7	TA/DA/ staff (SRF/ YP/RA) / Consultancy/ Miscellaneous etc.	30.0	30.0	20.0	20.0	10.0	110.0
	Total	125	125	85.5	70	45	450.5

Part-VI : Modalities

This programme is undertaken to enhance the fodder production, conservation and utilization on more sustainable basis in different fodder deficit districts of Rajasthan. The ICAR- IGFRI will lead in technological support in collaborating with other public and private sector agencies in this regard. However, the modalities of executing this programme are as follows:

- ICAR- IGFRI will be knowledge partner and will help in providing all technical backup, technological support, seed procurement, sources etc.
- ICAR-IGFRI will provide all the technological and technical support in implementation of fodder action plan
- ICAR-IGFRI will also supply the seeds/planting material or else will facilitate for the same from reliable sources in case of non-availability locally
- ICAR-IGFRI would help in seed procurement on buy back arrangement in cases where seed production activities are involved in the programme
- Line Departments *viz*. Dept. of Agriculture, Dept. of AH & VS, Dept. of Horticulture, Dept. of Forestry etc., Govt. of Rajasthan along with KVKs, NGOs, Milk Federation etc. will implement the programme at field and farmers level.

Annexure-I

Proceedings of online workshop on 'Fodder Resource Development Plan for Rajasthan' held on July 10, 2020

One day online workshop on 'Fodder Resource Development Plan for Rajasthan' was organised on July 10, 2020 by ICAR-Indian Grassland and Fodder Research Institute (IGFRI), Jhansi in collaboration with Department of Animal Husbandry, Govt. of Rajasthan and Directorate of Agriculture, Govt. of Rajasthan. Meeting began with the welcome address by Dr. Vijay Kumar Yadav, Director, IGFRI, Dr. Yadav apprised to the auspicious gathering regarding importance of livestock production in livelihood of rural people especially in area of arid and semi-arid regions and future needs and scope of fodder resource development in Rajasthan. He also summarized about research accomplishments on fodder resource development, conservation and utilization at IGFRI and AICRP-FCU centres.

Dr. J.S. Sandhu, Hon'ble Vice Chancellor, SKNAU, Jobner in his inaugural address, appreciated the efforts made by IGFRI for organising the workshop on such an important subject like fodder resource development at the right time. Dr. Vishnu Sharma, Hon'ble Vice Chancellor, RAJUVAS, Bikaner in his inaugural address appreciated the efforts of IGFRI in this direction.

Dr. SS Meena, PS, IGFRI, Avikanagar presented agro-climatic zone-wise scenario of livestock production and fodder resources of the Rajasthan, SWOT analysis, plan for fodder resource development for the Rajasthan state. Dr. A.K. Roy, PC, AICRP-FCU presented list latest varieties and production technologies of various fodder crops developed and recommended for varied agro-climatic zones of Rajasthan. Dr. Sunil Kumar, Head, Division of Crop Production, IGFRI, presented fodder production technologies suitable for different agro-climatic conditions of Rajasthan. Dr. RV Kumar, Head, Division of Grassland & Silvipasture Management, IGFRI presented importance of round the year fodder production from non-arable lands. Dr Sunil Kumar PS (GSM), IGFRI presented hortipasture technologies suitable to state. Dr. Sultan Singh, PS, IGFRI presented fodder based rationing and conservation technologies.

Dr. Pradeep Saraswat, Additional Director (Farm & Estate), DAH, Govt. of Rajasthan, briefed about animal husbandry status of the state..

The workshop ends with formal vote of thanks to all the dignitaries and participants for attending the workshop and contributing valuable inputs by Dr. Purshottam Sharma.Proceedings of online workshop on 'Fodder resource development plan for Rajasthan'held on July 10, 2020

One day online workshop on 'Fodder Resource Development Plan for Rajasthan' was organised on July 10, 2020 by ICAR-Indian Grassland and Fodder Research Institute

(IGFRI), Jhansi in collaboration with Department of Animal Husbandry, Govt. of Rajasthan and Directorate of Agriculture, Govt. of Rajasthan. Meeting began with the welcome address by Dr. Vijay Kumar Yadav, Director, IGFRI, Dr. Yadav apprised to the auspicious gathering regarding importance of livestock production in livelihood of rural people especially in area of arid and semi-arid regions and future needs and scope of fodder resource development in Rajasthan. He also summarized about research accomplishments on fodder resource development, conservation and utilization at IGFRI and AICRP-FCU centres.

Dr. J.S. Sandhu, Hon'ble Vice Chancellor, SKNAU, Jobner appreciated the efforts made by IGFRI for organising the workshop on such an important subject like fodder resource development at the right time. There is imbalance in the fodder demand and supply throughout the state which is varied area-wise. There is need for increasing fodder production and proper distribution so that fodder may be supplied to deficit area in time by adopting the improved fodder production technologies developed by IGFRI. He also emphasized need to evaluate the residue level of pesticide in the fodder/crop residue being fed to the animals and ultimately reaches in human beings.

Dr. Vishnu Sharma, Hon'ble Vice Chancellor, RAJUVAS, Bikaner appreciated the efforts of IGFRI in this direction. He emphasized fodder bank concept and use of densification technologies in providing balanced ration to animals. It is also pointed out that there is lack of availability of quality seed of fodder crops in the state and which is great issue regarding adoption of high fodder yielding varieties by the farmers. Surplus fodder need to be conserved by silage/hay and make its availability in the deficit area by using proper machines for compression of bulky fodder.

Dr. SS Meena, PS, IGFRI, Avikanagar presented agro-climatic zone-wise scenario of livestock production and fodder resources of the Rajasthan, SWOT analysis, plan for fodder resource development for the Rajasthan state. Dr. A.K. Roy, PC, AICRP-FCU presented list latest varieties and production technologies of various fodder crops developed and recommended for varied agro-climatic zones of Rajasthan. Dr. Sunil Kumar, Head, Division of Crop Production, IGFRI, presented fodder production technologies suitable for different agro-climatic conditions of Rajasthan. Dr. RV Kumar, Head, Division of Grassland & Silvipasture Management, IGFRI presented importance of round the year fodder production from non-arable lands. Dr Sunil Kumar PS (GSM), IGFRI presented hortipasture technologies suitable to state. Dr. Sultan Singh, PS, IGFRI presented fodder based rationing and conservation technologies.

Dr. Pradeep Saraswat, Additional Director (Farm & Estate), DAH, Govt. of Rajasthan, pointed out that animal husbandry is one of the main enterprises of rural people which contribute about 25% in the GDP of agricultural of the state. He stated that there is shortage of dry fodder, green fodder and concentrate which vary widely from region to

region within the state. There is need of special drive for motivate the farmers for adopting various established technologies developed by IGFRI, ICAR institutes and, state agricultural universities.

Major recommendations

- There is great scope for enhancement of fodder production through establishment of improved pasture/rejuvenation of degraded pastures land and CPRs.
- For recommended fodder varieties, range grasses and legume; quality seed production, timely indent and procurement should be ensured.
- Pearl millet and sorghum are main crops that contribute maximum green and dry fodder. But in recent years share of hybrid has increased and they produce more grain and less stover/fodder which is adversely affecting the fodder supply in Rajasthan. The dual type varieties of these crops for enhancing fodder supply should be developed.
- By adopting three tiers system (trees + shrubs + grasses/ legumes) of silvi-pasture/horti-pasture system in rainfed/irrigated areas of Rajasthan, perennial grasses on bunds can be potential fodder technologies for state.
- The surplus fodder produced during monsoon season may be conserved by silage/hay making. Leave and pod of fodder trees, shrubs are vital fodder component in arid and semi-arid regions which are rich in protein for small ruminants.
- Commercial rearing of small ruminants is being adopted more. Inclusion of new fodder resources e.g. azolla, moringa, mulberry etc. will be helpful in meeting the nutrient requirements of small ruminant where grazing resources are decreasing.
- Intensive fodder production technologies can be promoted in irrigated condition such as Kota and Bundi districts, while suitable technologies for rainfed fodder should be encouraged in Sawai Madhopur and Karouli districts.
- Pastures can be established and maintained by sharing the responsibilities among implementing agency, technical knowledge providing agency and user community. Convergence with existing schemes such as MANREGA may also be explored for development of CPRs in each block.
- Keeping in view the success achieved earlier, integrated fodder development schemes like AFDP can be reintroduced in the state.

The workshop ends with formal vote of thanks to all the dignitaries and participants for attending the workshop and contributing valuable inputs by Dr. Purshottam Sharma.

Annexure-II

List of participants of online workshop on 'Fodder plan for Rajasthan' on July 10, 2020,

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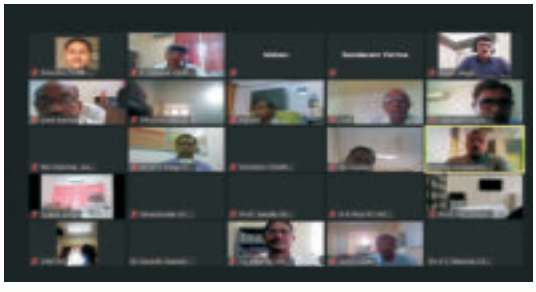
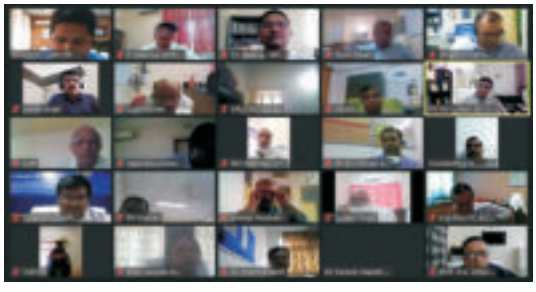
51.	Sri Mahaveer Prasad	
52.	Sri Prakash Singh	
53.	Dr. Ashok Dangi	
54.	Prof. Sanjita Sharma	
55.	Ms. Barkha Gupta	

Glimpses of workshop





Developed Fodder Crop Varieties from ICAR-IGFRI, Jhansi

Crop	Varieties	GFY (t/ha)	Recommendation for cultivation	Year of release
Berseem	Wardan	65-70	Whole country	1981
	Bundel Berseem 2	65-80	Central, NW zone	1997
	Bundel Berseem 3	68-83	NE Zone	2000
	JBSC-1	38-40	North west zone	2017
Lucerne	Chetak	140-150	North west central	1975
Oat	Bundel Jai 822	44-50	Central zone	1989
	Bundel Jai 851	40-50	Whole country	1997
	Bundel Jai 99-2	40-50	North West Zone	2004
	Bundle Jai 2004	50	North east and north west zone	2002
	Bundel Jai 2009-1	53-62	Central zone	2016
	Bundel Jai 99-1	35-40	Hill Zone	2007
	Bundel Jai 2010-1	27-34	South Zone	2015
	Bundel Jai 2012-2	33-37	South Zone	2017
	Bundel Jai 2015-1	25-30	Hill Zone	2018
Cowpea	Bundel Lobia 1	25-30	Whole country	1992
	Bundel Lobia 2	25-30	North Zone	1992
	Bundel Lobia 4	23-26	North-eastern Zone	2012
Guar	Bundel Guar 1	25-35	Whole country	1993
	Bundel Guar 2	30-40	Whole country	1994
	Bundel Guar 3	30-40	Whole country	1999
Field bean	Bundel Sem 1	25-35	Whole country	1993
Anjan grass	Bundel Anjan 1	30-35	Whole country	1989
Cenchrus	Bundel Anjan 3	30-35	Whole country	2006
ciliaris	Bundel Anjan-4	35-37	Whole Zone	2019
Dhaman grass *Cenchrus setigerus*	Bundel dhaman -1	13-15	Western part of country	2019
Dinanath grass	Bundel Dinanath 1	55-60	Whole country	1987
	Bundel Dinanath 2	60-65	Whole country	1990

BN hybrid	Swetika	100-120	Central, northern and north eastern areas	1983
Bajra-squamulatum hybrid	BBSH-1	30-33	Western and northern part of country	2019
Butterfly pea	Bundel clitoria-1 (JGCT-2013-3)	25	All India	2017
Bajra	AVKB-19 JHPM-05-2	50-60 70-80	Whole country Whole country except south zone	2007 2008
Guinea grass	Bundel guinea 1	40-50	Punjab, HP, Central UP, Maharastra, Tamilnadu	2004
	Bundel guinea 2	50-55	Rainfed conditions in semi-arid, tropical, sub-tropical and humid tropics	2008
	Bundel guinea 4	75-81	All guinea grass growing areas	2012
Sehima	Bundel Sen Ghas -1	18-20	Semi-arid, tropical and sub-tropical areas across the country	2007
Chrysopogon	Bundel Dhawalu Ghas-1	26-30	Rangelands under rainfed condition across the country	2007
Heteropogon	Bundel Lampa Ghas-1, IGHC-03-4	25-30	Rangelands under rainfed condition across the country	2007
Dichanthium	Bundel Marvel Grass-2013-2 (JHD- 2013-2)	35-45	NWZ particularly for Punjab and Rajasthan	2017

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