भाकृअनुप
ICAR

ANNUAL REPORT
1995 - 96

INDIAN GRASSLAND AND FODDER RESEARCH INSTITUTE

IGFRI

ANNUAL REPORT
1995-96

INDIAN GRASSLAND AND FODDER RESEARCH INSTITUTE
JHANSI - 284003 INDIA

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PREFACE

The forage production in the country is not sufficient to meet the requirements of the ever increasing livestock population. The Indian Grassland and Fodder Research Institute has the national mandate for conducting the basic, applied and strategic research on all aspects of forage production and utilization, which has direct impact on developing forage and feed resources to achieve the goal of feeding such a huge livestock population in the country. Mission oriented research efforts are under way for the development of economically feasible forage production systems suitable for different farming situations under various agro-climatic zones of the country. The Institute is also engaged in transfer of suitable technologies through organised training programmes, field demonstrations and other extension methods. Special efforts are being made to strengthen the research and infrastructural support facilities.

I feel great pleasure in presenting the Annual Report for the year 1995-96. The progress of research projects has been reported divisionwise. I hope that the information embodied will be of immense utility to all those engaged in the field of forage production and utilization.

I express my heartiest thanks to all the Heads of Divisions and the members of the Technical Cell for compilation and editing of the report.

Bhag Mal

(BHAG MAL)
Director

September 30, 1996

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GENERAL

INTRODUCTION

Indian Grassland and Fodder Research Institute was established by the Government of India at Jhansi in the year 1962 to initiate organized research programmes in the field of grasses, grasslands and fodder crops. Later on, in the year 1966, administrative control of the Institute was transferred to the Indian Council of Agricultural Research. Since then, the Institute has made concerted efforts in conducting, collating, and coordinating research, training and extension programmes on all aspects of forage production and utilization through inter-disciplinary research programmes. The Institute has made significant research contribution in the field of forage plant improvement, grassland production and improvement, agro-silvipasture, agronomy, plant protection, conservation and post-harvest technology, seed technology and forage utilization. Technology transfer programmes have been given highest priority and the seed production programmes have been strengthened.

THE MANDATE

1. To conduct basic and strategic research on forage crops and grassland management.

2. To sustain, enrich and enhance forage germplasm.

3. To disseminate the technology developed for effective adoption.

4. To establish national and international linkages in the mandate areas of the Institute.

5. To extend consultancy and expertise in the area of fodder, forage and feeds.

ORGANIZATION

The Institute is organized into twelve scientific divisions, nine central units and three regional stations.

The scientific divisions are: (i) Plant Improvement (ii) Agronomy (iii) Grassland Management (iv) Soil Science (v) Agrosilvipasture (vi) Plant-Animal Relationships (vii) Seed Technology (viii) Plant Physiology and Biochemistry (ix) Plant Protection (x) Agricultural Engineering and Post-Harvest Technology (xi) Rural Economics and Biometrics (xii) Extension and Training.

The nine central units are: (i) Administration (ii) Audit and Accounts (iii) Estate (iv) Central Research Farm (v) Library (vi) Technical Cell (vii) Photography and Arts (viii) Central Laboratory Services and (ix) Medical Unit.

The Headquarters of All India Coordinated Project for Research on Forage Crops is located at this Institute. The Inter-Institutional Collaborative Network Programme on Crop based Livestock

Feeding System has been initiated this year. The Institute houses research centres for All India Coordinated Research Projects on: (i) Dryland Agriculture (ii) Agroforestry (iii)Under-utilized/Under-exploited Plants (iv) Farm Implements and Machinery Prototype Testing and Feasibility. The projects on (i) National Seed Production (ii)NAEB Pasture Seed Storage in relation to its Quality (iii) NDDB supported Compaction, Storage and Transportation of Crop Residues and Grasses (iv) NARP Training Programme (v) Inventory of Grazing System and Pastoralism in India (vi) Photosynthesis and Shade Tolerance in Tropical Range Grasses and Legumes (vii) DST Flood Hazard in the Rapti - Burhi Rapti Region (viii) Cess Fund Project on VAM fungi in Management of Root-knot and Stunt Nematodes on Berseem, Lucerne and Cowpea are also located at this Institute.

The Institute has two international projects *viz.*, IDRC-IGFRI Silvipasture Operational Research Project and Indo-U.K. Collaborative Research Project on Forage Production.

Three regional stations of the Institute are located at CSWRI, Avikanagar in Rajasthan, Tegur near Dharwar in Karnataka and Srinagar in J&K for conducting research in various agroclimatic regions of the country.

RESEARCH COLLABORATION

The Institute has following collaborative research programme with various Institutes/Organizations at the national and international levels.

All India Coordinated Research Project on Forage Crops

The coordinating unit of the project is located at the Institute. The project has major mandate of identifying high yielding varieties and production systems for various agroclimatic zones through its research centres located throughout the country. Through this project, the Institute has established linkages with various state agricultural universities and research Institutes in the country. The project is coordinating activities of 24 centres in the country, one being at Jhansi.

This project celebrated its silver jubilee in the December, 1995. The function was inaugurated by the Dr. R.S. Paroda, Secretary, DARE and Director General ICAR.

Network Collaborative Project on Crop based Livestock Production System

The project has the major objective of studying the effect of different animal management practices on soil and ecological changes as well as biomass and livestock production, evaluating the economics and sustainability of the system, and extending the results to the farmers.

Breeders Seed Production Project

The National Seed Project located at this Institute is operative to strengthen the research capabilities for varietal improvement, varietal testing and

uninterrupted basic and breeder seed production. The seed production of released or notified varieties of cultivated forage crops is taken up as per the allotment of Ministry of Agriculture and Project Coordinator (FC).

NARP Training Centre

The centre of National Agricultural Research Project has been functioning to strengthen training facilities in the field of agroforestry, forage production and animal nutrition. The training programme has been designed for NARP Scientists / Professors for 30 days duration.

IDRC-IGFRI Project

The objective of this project is to increase the overall forage and tree crop productivity of the degraded grazing lands and wastelands to semiarid pastoral areas by interplanting fast growing trees with grasses and legumes that have high potential for animal feeds (includes pasture and leaf fodder) and firewood production. The project successfully completed its second phase in June, 1996 and the results were published in the form of a bulletin.

Indo-U.K. Collaborative Research Project

The ODA supported collaborative project on forage production has the major objectives to strengthen the research capabilities of the Institute. The components of the project includes bilateral research in frontier areas; training of IGFRI staff in UK, India, and other countries; consultants visits; acquisition of modern equipments, etc.

STAFF

The Institute has a sanctioned strength of 160 Scientific, 137 Technical, 82 Administrative, 157 Supporting and 36 Auxiliary staff. The staff position is given in Appendix I.

FINANCE

During the year 1995-96, the Institute utilized budget grant of Rs 504.54 lakhs out of which Rs 134.00 were utilized under plan and Rs 370.55 lakhs under non-plan. During the year, revenue of Rs 21.27 lakhs was realized. The head wise expenditure statement is given in Appendix II.

FACILITIES

Central Research Farm

The Institute farm has a total area of 574 ha, which also includes the area under campus and area given to National Research Centre on Agroforestry. The farm has varying topography with *rakar, parwa* and *kabar* types of soils.

Administrative Wing and Research Laboratories

Until this year, the Research Laboratories complex comprised of five laboratory wings and one administrative wing. One more

wing of the laboratory was added on the first floor of the third wing. This was inaugurated by Dr. R. S. Paroda, Secretary, DARE and Director General, ICAR during December, 1995. There is a well furnished Conference Hall and Committee Room for Symposia/Conference etc. The laboratories are well equipped with fixtures and furnitures and sophisticated instruments. The Central Analytical Laboratory and Central Instrumentation Laboratory provides centralized research services for chemical analysis and instrument repairs and maintenance.

Computer Centre

The Institute has a number of personal computers connected over a Ethernet Local Area Network for information management and data analysis. The institute is also having connectivity to national and international networks through NICNET.

Library

The Institute library accessioned 7754 books, besides, reports/bulletins/books received on complementary basis during the year. The library subscribed for 90 Indian and 58 Foreign journals. Library is also providing current awareness service to the scientists. The dissemination of information is provided to Ph.D. scholars and scientists from other organizations and library consultation facility from time to time. The reprographical services are also available. The copies of the reprints of the article are also sent free to the indenters.

Photography and Art Unit

The photography and art unit undertakes the preparation of charts, maps, illustrations and slides. The facility for preparation of coloured photographs is also available.

Residential Complex

The residential campus named Krishi Nagar has 140 quarters of various categories. It has a community centre along with recreation and playground facilities with necessary infrastructure for providing better social life to the residents. State government aided primary school is also functioning in the Campus.

Scientist Home and Guest House

The eleven suit Scientist Home is annexed with 25 rooms PG Training Hostel. The VIP Guest House is having three AC suits.

Medical Unit

The Medical Unit is located in the premises of the Institute with a Medical Officer and other auxiliary staff. The available facilities are providing better health care to the staff and their family members.

Weather

From April 1995 to March 1996, a total amount of 850.4 mm rainfall was recorded

in 52 rainy days. In the year 1995, onset of monsoon was recorded in 3rd week of June i.e. 25th standard meteorological week. After 4 days of rain only, an effective break of 15 days was experienced, thereafter monsoon was again active from 2nd weak of July to 2nd weak of September i.e. from 28th to 37th standard meteorological week (726.4 mm in 40 rainy days). A good amount of winter rain (60.8 mm) was recorded in 6 rainy days, which was useful for *rabi* crops.

The peak maximum temperature of 46.6°C on 2nd June 95 and peak minimum temperature of 1.8°C on 30th January 96 were recorded. The highest values of evaporation (21.2 mm/day) on 9th June 95, bright sunshine hours in a day (12.0 hrs) on 25th and 26th June 95 and wind velocity (16.8 km/hrs) on 26th July 95 were recorded. Maximum values of soil temperature of 56.0 °C at 5 cm depth on 7th June, 47.0 °C at 10 cm depth on 6th, 7th and 8th June and 40.4 °C at 20 cm depth on 12th June 95 were recorded at 14.16 hours of the day (Table 1).

Table 1 : Meteorological data recorded at Central Research Farm, IGFRI, Jhansi

Months	Temp. °C		RH % period		Rainfall (mm)	Rainy days (No.)	Wind velocity (km/hr)	Bright sunshine (Hours/day)	Evaporation (mm/day)
	Max.	Min.	Ist	IInd					
Apr. 95	38.3	15.6	58	23	002.6	1	2.7	9.8	9.0
May 95	43.1	26.0	36	20	000.0	0	6.3	10.6	13.9
June 95	41.7	27.2	62	36	060.6	5	8.1	8.2	12.6
July 95	34.7	25.4	83	61	360.2	15	7.8	5.4	6.8
Aug. 95	31.3	23.4	96	77	211.0	17	4.1	4.9	3.4
Sep. 95	23.0	22.3	92	61	155.2	8	3.1	7.6	4.4
Oct. 95	33.9	16.3	88	31	000.0	0	1.5	9.9	4.3
Nov. 95	29.0	10.0	86	29	000.0	0	1.5	9.6	3.6
Dec. 95	24.4	7.2	94	40	006.6	1	0.9	8.2	2.5
Jan. 96	22.1	6.8	96	52	043.4	3	1.6	7.6	2.1
Feb. 96	26.5	9.1	95	47	010.8	2	2.6	8.8	3.9
Mar. 96	34.2	14.9	77	24	000.0	0	4.2	10.0	7.1

DIVISION OF PLANT IMPROVEMENT

PI-1: COLLECTION, EVALUATION AND MAINTENANCE OF GENETIC RESOURCES OF FORAGE CROPS

1.1 Grasses

(S.R.Gupta, A.K.Roy, D.K.Agarwal and Sanjeev Gupta)

Collection : Sizable Genetic diversity among perennial grasses comprising 429 accessions of *Dichanthium annulatum, Sehima nervosum, Heteropogon contortus and Iseilema laxum* were collected from places in and around Jhansi, Lalitpur, Shivpuri and Datia districts.

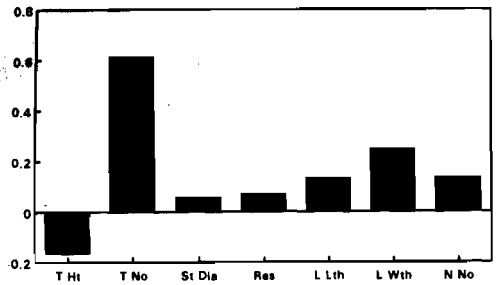
Evaluation : Strains of *Dichanthium annulatum, Sehima nervosum, Chrysopogon fulvus, Heteropogon contortus* and *Iseilema laxum* were evaluated for green fodder yield and other related morphological attributes and some promising strains were identified (Table 2).Data were also recorded to establish suitable selection criterion (Fig.1).

Data on morphological attributes from 56

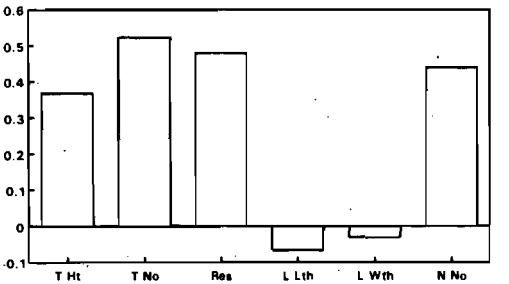
Table 2 : Performance of different strains of various perennial grasses under rangeland conditions

Characters	Grasses				
	Dichanthium annulatum	*Sehima nervosum*	*Heteropogon contortus*	*Iseilema laxum*	*Chrysopogon fulvus*
Tussock Height (cms)					
Mean	122.34	99.67	-	117.50	172.21
SD	18.18	4.88		10.81	5.04
Tussock Weight (g)					
Mean	451.84	922.90	638.20	479.58	1697.83
SD	152.76	123.95	388.29	167.83	143.93
No.of Tillers					
Mean	244	478	116	212	184
SD	89.70	65.76	52.83	72.79	14.95
L/S Ratio (Green matter)					
Range	0.55-1.68	0.46-1.71	0.48-1.51	0.79-1.82	0.48-1.04
% Dry Matter					
Range	41.05-62.58	48.41-61.70	52.96-68.31	47.19-65.81	51.55-55.87
Promising Accessions	IG 2220,IG 2219 IG 2002,IG 2000 IG 2173	IG 2048,IG 2036 IG 2061,IG Local	- -	- -	IG 2008, IG 2047

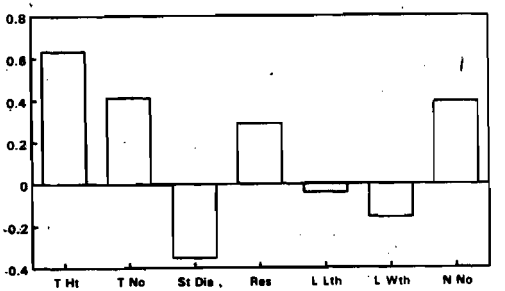
Chrysopogon fulvus



Dichanthium annulatim



Sehima nervosum



T Ht = Tiller Height, T No = Tiller Number, St Dia = Stem Diameter, Res = Residual

L Lth = Leaf Length, L Wth = Leaf Width, N No = No. of nodes

Fig. 1 : Contributing Traits Towards GFY

accessions of *Dichanthium annulatum* was subjected to cluster analysis. The accessions were categorized into 8 clusters using 6 important principal components. The number of accessions within clusters varied from 3-9. The clustering pattern indicated that genetic diversity is not localized and is well distributed over different regions. The maximum cluster distance was found to be 5.051 while the minimum was 1.801. Average distances of cluster members from cluster centroid varied from 1.336 to 1.662.

Maintenance : The available genetic diversity among various perennial grasses is being maintained under *ex situ* conditions. Old collections were rejuvenated by transplantations and/or through seed.

1.2 Legumes

(U.P. Singh)

Evaluation

Clitoria ternatea

IGFRI-1531-1 recorded highest green fodder yield and dry matter yield (286.0 and 83.3 q/h respectively) followed by IGFRI-23-1 with 280.5 and 82.2 q/h green and dry fodder yield respectively in CAVT comprising 11 entries.

Guar

Nine entries of Guar including two national checks were evaluated for various seed production aspects. Highest quantum of seed was observed in variety RGC - 1001 (15.6 q/h) followed by better check GG-1 (13.6 q/h seed). However,maximum number of pods/plant were found in RGC-1000 (137.6 pods), while comparatively bold seeds were observed in CAZG -11 and RGC-1001 with 3.66 (g) test weight for 100 seeds against the control variety with 3.36(g).

PI-2 : PRODUCTION AND QUALITY BREEDING IN FODDER GRASSES

2.1 Breeding superior varieties of forage sorghum

(D.S.Katiyar and U.S.Mishra)

Evaluation of germplasm

Two sets of Sorghum germplasm were evaluated with HC-171 and SSG 59-3 as controls after every 25 lines . The first set of material contained 40 single plant progeny lines developed through interspecific hybridization using two male sterile lines i.e. I.S. 2219 A and IS 2077A and three species (used as pollinators) namely Etawah-2 and 18677 *(S. bicolor), S. lanceolatum* and *S. aethiopicum*. The segregating material yielded both single and multicut plant types.Based on overall superiority seven progenies were identified.

The second set contained 363 lines in (F_7,F_8,F_9 generations) received from NRC, Hyderabad. Twenty two lines exhibited good regrowth potential and there was wide genetic diversity among the single cut type plants.

Evaluation of promising strains

Initial evaluation trial: Forty five strains, 42 developed through hybridization and 3 from germplasm selection, were evaluated along with HC-171 as control for single cut system. Thirteen superior strains outyielded the control.

Seven strains developed through hybridization and one from germplasm selection were evaluated for multicut system. Three strains produced higher yield over the control.

Final evaluation trial

Six superior strains developed through hybridization were evaluated along with two checks i.e.H.C-171 and S-308. Two strains i.e.2219A X I-1-3-1, 4-1-2-3 and 2219A X I-1-3-1,4-1-1-1 showed more than 10% superiority over the best check (S-308)(Table 3).

Table 3 : Performance of promising strains of sorghum in initial evaluation trial for multicut system during *kharif* 1995

S. No.	Strains	Mean values of Plant height	No.of leaves/ Plant	Leaf length cm	Leaf width cm	Green fodder yield q/ha
1.	SSG-59/3 (Control)	197.7	12.0	87.4	5.3	499.5
2.	I.S. 19021	179.4	15.9	92.9	7.1	166.5
3.	2077A X 13677 4-4-1-3	185.2	13.8	96.0	6.9	540.2
4.	2077A X S.lanceolaturm 2-12-1-3-2	172.9	13.8	117.0	8.4	503.2
5.	-do- (2-3-1-2-2)	187.2	13.7	99.8	7.8	462.5
6.	2219 A X Etawah-2 (3-2-3-3-4)	181.7	14.3	95.2	6.4	532.8
7.	-do- (6-1-2-1)	172.7	11.7	91.3	6.9	473.6
8.	2219 A X I-3-1-1 (7-3-2-2)	184.5	12.1	99.5	7.2	510.6
9.	229 A X Etawah -2 20-1-2-2	203.9	14.6	97.5	7.4	536.5
	10% + over the check yield in q/ha					549.50

Hybridization and advancing of filial generation

Crosses were attempted to obtain F_1 hybrids, using 10 m.s. lines along with their counterparts (B line) and 10 pollinators. Keeping in view the forage attributes and especially the nonsenicent/ behaviour of the plant, green midrib and low grading for disease a number of hybrids and their progenies were advanced.

All India coordinated research project on forage sorghum

Three entries were contributed for testing in different categories at all India level.

HD -15	-	Promoted to final evaluation trial.
J.Sel-15	-	Retained for initial evaluation.
J.Sel-10	-	Final evaluation trial retained for single cut system.

2.2 Production and quality breeding in fodder oats (*Avena sativa* L.) and forage *Pennisetums*

(R.N.Choubey, S.N.Zadoo and A.K.Roy)

Fodder oat

Germplasm evaluation : Six hundred fifty five accessions of *Avena sativa, A. sterilis, A. strigosa and A. brevis* were screened for a set of 12 descriptors in augmented design. Wide variation was observed for various traits.

A number of accessions namely, CI-9299, 9304, 9308, 9325, PI-497730, 497736, 497811, 497880, PA-2714, 2761, 2789, BGP-56, 59, 68, 86, 90, 93 and 92, H(R3)-49 were identified with long stature, high leafiness, and high tillering suitable for their use in forage oat breeding programme.

Segregating progenies : Four hundred ten segregating progenies in F_3, F_4 and F_5 generations were subjected to intensive selection pressure to select elite plants/ progenies. Selections with high forage yield and related desirable traits, were derived from the cross combination like (OS-7 X IGO - 320) X Cuahtemoc, (OS - 6 x H.valco), (Black mesdag X Tazejnic), (PA-8224 X Black Nip), (Black mesdag X PA -8224), (Flemmingold X Pennline), (Orbit X CI- 9170), (OS-6 X H.Valco), (OS-7 X IGO 320) X JHO-801 and (OS-7 X IGO-320) X Black Nip.

One hundred fifty six progenies in F_6 and F_7 generations were grown and a number of desirable plants/ progenies with useful plant traits were selected for generation advancement.

One hundred thirty five advance generation (F_7-F_8) progenies were tested against the check (UPO -212) for their performance with respect to forage yield. The range of superiority over the check varied from 5.8 to 43.5%. Maximum level of superiority was exhibited by (UPO-94 X IGO -320) X Akiyutaka, followed by (Flemmingold X Pennline), (OS-6 X Akiyutaka), (OS-6 X JHO 851) and (UPO -94 X Diamante).The progenies like (OS-

6 X Cuahtemoc), (OS-6 X Diadem) and (OS-6 X H.Valco) were highly leafy.

Back-cross progenies: Sixty backcross derived progenies *(A. sativa X A. sterilis)* and check (UPO-212) were grown. The highest forage yield was of (OS-6 X *A. sterilis*)-E showing 21.7% increase over the control. This was followed by (OS-6 X *A. sterilis*)-3-2 and (OS-6 X *A. sterilis*)-D with 18.0 and 15.4 % increase over the check, respectively. These progenies were having longer growth duration and high leafiness.

Amphiploid progenies : Two hundred sixty amphiploid derivatives of the interspecific crosses between *A. maroccana* and 3 genotypes (OS-6, UPO -94 and JHO-801) of *A. sativa* were grown in A_{10} generation. Screening with respect to morphological traits indicated a wide range of variation. Cytological analysis of a number of plants exhibited varying chromosome numbers, from hexaploid to decaploid.

Thirty one amphiploid derived progenies were studied for detailed cytological and morphological parameters. In *A. sativa* genome background, although the chromosome number has stabilized at the euploid genome level of *A.sativa* (2n=6x=42), yet the spikelet characters *viz.,* number of awns, character of awns, lemma pubescence and lemma colour were found in various new combinations in the progenies. It indicates breakage of linkages and expression of new characters and possible exploitation of introgression for superior agronomical traits.

Station trial : An unreplicated multicut trial was conducted with 68 genotypes collected from diverse sources. Maximum green forage yield was scored by Centennial having 37.9% superiority over the check followed by Larry, JHO-40, IGO-1120, IGO-1324 and IGO-1319 recording 14.7, 10.5, 10.4, 10.4, and 6.3% increase over the check , respectively.

All India coordinated trial : Testing of 15 varieties including JHO-94-1, 94-2, 94-3, and 94-4 in initial varietal trial (multicut) indicated that JHO-94-3 had maximum dry matter yield i.e.7.6 per cent increase over the check in central zone. While performance of JHO 94-1 for green forage yield was found better than the check in north-east zone.

In advance varietal trial, 15 entries including 5 varieties i.e. JHO-891, 892, 893, 995 and 996 from Jhansi were tested under multicut with respect to green forage yield, OS-196 ranked first in south zone followed by JHO-892 showing 32.6 and 30.1% superiority over the check, respectively. However, the results with respect to dry matter yield in south zone indicated the superiority of JHO-892 followed by JHO-995 and JHO-891 showing increase over the check as 82.7, 68.6, and 65.6% respectively.

Pennisetums

Testing of N-B hybrids in all India coordinated trials : Three newly developed hybrids BN-9201, 9202 and 9203 were multiplied for testing in advance varietal trial.

Hybridization programme : Interspecific hybridization was attempted between various *Pennisetum* species namely, *P. typhoids, P. purpureum, P. squamulatum* and *P. pedicellatum.*. Except the cross between *P. typhoides* and *P. purpureum* no success was achieved.

PI-3 : BREEDING SUPERIOR VARIETIES OF CULTIVATED FODDER LEGUMES

3.1 Breeding varieties for higher yield and quality in cowpea

(K. S. Kohli and C. B. Singh)

Maintenance and evaluation of germplasm

200 germplasm lines (hybrid derivatives) in advanced generation were maintained and evaluated with two control varieties, namely, Bundel Lobia 1 and 2. Dual purpose types (seed cum fodder) were isolated for further evaluation.

Institute trial

The Institute trial comprised 16 dual purpose, erect growing types (selected the previous year) for testing their suitability as fodder cum seed crop. Out of these 3 lines have been isolated for further testing in grass-legume combination.

All India coordinated trials

Initial evaluation trial (KBTC 1) : The institute entries IFC 9502 and 9503 produced maximum green fodder (430.55 and 405.56 q/ha, respectively) and dry matter yield (60.15 and 52.43 q/ha, respectively) as compared to other entries.

Final evaluation trial (KBTC 2): The institute entries IFC 9304 and IFC 9402 produced significantly higher green fodder (422.22 and 411.11 q/ha, respectively) and dry matter yield (62.90 and 58.36 q/ha, respectively) as compared to other varieties including best control.

3.2 Strain building in lucerne for yield and persistence

(C.B.Singh, K.S.Kohli and P.K.Katiyar)

Germplasm

482 germplasm lines of lucerne including 260 new and 222 old collections were grown. The new collections comprised materials from Himachal-57, Rajasthan-112, Maharastra-38, Gujrat-39, Punjab-8, U.P.-7 and Coimbatore-1, the old germplasm included 103 indigenous and 89 exotic lines.

Inter- clonal variation

One year old 212 individual plants (clones) were selected covering a wide range of genetic diversity from different germplasm materials. The data were subject to non-hierarchical cluster analysis. A total of 14 morphological groups were identified.

The characteristic features of different cluster and/or cluster groups are as under:

Cluster 1: Medium statured plant with low values for most of the characters but

with long internodes and long leaves.

Cluster 2 and 9: Short statured plants with low values for most of the characters and poor forage yield. The cluster number 2 had round leaves and 9 long leaves.

Cluster 3 and 6: Medium statured plants with few tiller number, thin stem and poor forage yield. The cluster number 6 differed from 3 in having relatively taller plants and broader leaves.

Cluster 5 and 7: Plants medium statured, thin stemmed, few tillers and round leaves. The cluster number 7 had also high forage yield compared to poor forage yield in cluster 5.

Cluster 4 and 14: Vigorous plants with short internodes. The cluster 4 had more roundish leaves than cluster number 14.

Cluster 8 : Most vigorous,tall, thick stemmed, numerous internodes of short length and high forage yielding plant type.

Cluster 11: Tall, vigorous plants with high tiller number, round leaves, long internode type with medium yielding ability.

Cluster 13: Medium statured plants with high values for most of the characters except forage yield and stems with short internodes.

Correlations

Significant positive correlations were observed between plant height, stem girth, length of tallest tiller and green fodder yield per plant. The stem thickness was separately significantly positively correlated with length and width of the leaves. The leaf length, width and length/ width ratio were significantly correlated characters. The internode length was significantly correlated with the length of tallest tiller only.

All India coordinated trial

Among eleven varieties, LLC-2 and Comp-93 produced highest green fodder yield (205 and 201 q/h) followed by IL-244and LLC-9 with 193 and 191 q/h, respectively in three cuts. All other varieties produced less than 170 q/h in three cuts.

3.3 Genetic Improvement in *Trifolium alexandrinum* with special reference to Egyptian clover

(D. R. Malaviya)

All India coordinated trials

Two coordinated trials RBT-1 and RBT-2 were conducted. JHB 94-1 was found to have 15 % superiority over check Wardan for green fodder yield in RBT-2 at Jhansi centre. JHB 95-2 was found to have 13% superiority over check Wardan for green fodder yield in RBT-1.

JHB 94-3 ranked Ist in IET in NE zone whereas on All India average JHB 94-1 and JHB 94-4 ranked Ist and IInd respectively for green fodder yield. JHB 94-4 ranked Ist in both NE and central zone and IInd in All India average for dry matter yield.

JHB 92-2 ranked Ist in NE zone for green fodder yield; JHB 93-4 ranked Ist in south zone and also on All India average.

Station trial

One Station Trial comprising 10 diploid and 10 tetraploid lines was conducted and four cuts were taken.

Seven diploid and six tetraploid lines were evaluated against two checks for yield and its attributes. Wide genetic diversity among diploid and tetraploid lines was observed for leaf length, leaf width and stem diameter. Heritability in broad sense combined with genetic advance established that number of branches per unit row length was the best selection criteria both in diploid and tetraploid lines (Table 4)

Progeny evaluation

24 selected progenies along with cheek Wardan were evaluated. Two progenies viz. FAO 5 -2/14-15 and 9/12-13 out yielded the check Wardan.

Selections

162 selected single plant progenies have been grown and data has been recorded for segregation,yield performance and morphological features. These selections include multi-foliates, red flowered plants, leaf mutant and late types.

Table 4 : Range, mean, heritability, genetic advance, genotypic and phenotypic coefficient of variation in diploid (2x) and tetraploid (4x) Egyptian clover

	Ch1	Ch2	Ch3	Ch4	Ch5	Ch6	Ch7	Ch8
2x Range	37.7-50.8	3.2-3.9	3.8-4.4	1.3-1.5	7.5-8.8	51.3-93.6	70.1-83.1	9.9-13.2
Mean	45.25	3.57	4.14	1.43	8.09	78.7	78.21	11.41
4x Range	42.5-46.1	4.0-4.7	4.4-4.9	1.5-1.8	7.5-8.6	45.7-65.3	63.6-76.6	8.7-10.6
Mean	44.48	4.27	4.66	1.67	8.03	54.8	70.82	9.64
2x PCV	10.68	11.31	9.78	10.92	8.10	22.31	7.95	11.23
4x PCV	8.03	9.85	7.52	8.94	6.99	20.17	10.01	11.62
2x GCV	6.84	4.86	1.18	1.95	3.68	14.94	5.62	7.48
4x GCV	0.07	0.74	0.68	4.55	2.99	12.82	6.54	7.30
2x h^2	41.0	18.4	1.5	3.2	20.7	44.8	49.9	44.4
4x h^2	0.00	0.6	0.8	25.9	18.3	40.4	42.7	39.5
2x GA	4.08	0.15	0.01	0.01	0.28	16.22	6.39	1.17
4x GA	0.00	0.00	0.01	0.08	0.21	9.19	6.24	0.91

Ch1=Plant height, Ch2 =Stem diameter, Ch3= Leaf length, Ch4=leaf width
Ch5= No. of internodes, Ch6= No.of branches/unit length, Ch7=green fodder yield,Ch8=dry matter yield
H^2 = Heritability(%), GA = Genetic advance, GCV = Genetic Coefficient of variation
PCV = Phenotypic coefficient of variation

Mutation breeding

294 single plant progenies and 20 bulk progenies of irradiated population of three varieties, Wardan, IL40016 and IL40010 have been grown in M2 generation . Plants with high vigour, lateness and distinct characters have been identified/ selected.

Pathological observations

Seedling emergence test was conducted on 4 diploid and 12 tetraploid lines in seedling trays in control and sterilized soil condition. In another experiment, 4 diploid and 4 tetraploid lines were tested for seedling emergence under inoculated seeds followed with Bavistin -Thiram treatment. The experiment has given indication of some soil borne pathogen affecting seedling emergence.

Use of bees as pollinator

Maximum seed set was observed in open pollinated condition followed by controlled pollination using Italian bees. The seed set was drastically reduced when visit of insects/bees was checked using mosquito nets (Table 5).

Pollen fertility

Pollen fertility test among many single plant progenies in M_2 generation revealed

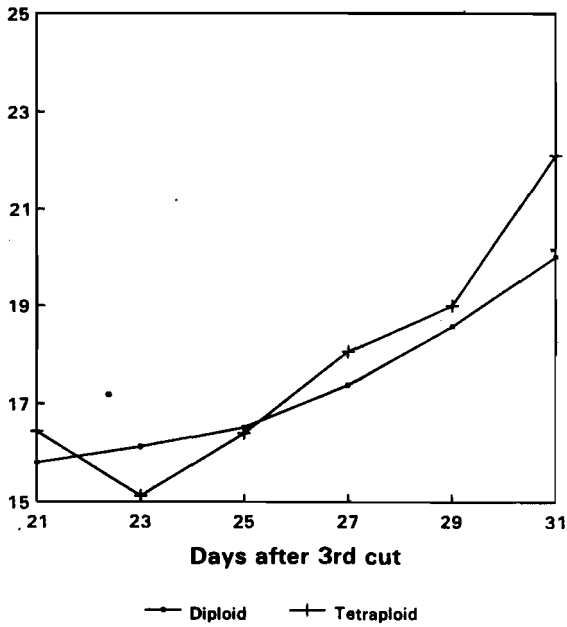


Fig. 2 : Dry matter accumulation (%) in diploid and tetraploid berseem

Table 5 : Number of seeds/inflorescence in different pollinating condition in berseem

	Open pollinated	Selfing under caged condition		
		Local bees	Italian bees	Without bees
Diploid				
Normal seeds	41.33	6.59	30.17	6.15
Malformed seeds	4.45	0.63	2.06	1.65
Tetraploid				
Normal seeds	14.06	3.65	7.77	0.55
Malformed seeds	1.44	0.45	0.93	0.20

near 100% pollen fertility in all the plants screened.

Dry matter accumulation

Data recorded on trend of dry matter accumulation in diploid and tetraploid berseem after 20 days of cutting to 30 days after cutting revealed almost similar trend of increasing dry matter percent both in 2x and 4x berseem (Fig. 2).

3.4 Breeding superior fodder varieties in Lablab bean *(Lablab purpureus)*

(D.N.Singh)

Evaluation and maintenance of the genetic stock

Observations were recorded on 140 genetic lines of the sub species *L. lignosus* and *L. typicus*. The entire genetic stock was classified in four groups as follows:

Early flowering type (Group I): Flowering took place between 73-78 days (First week of October)

Medium flowering type (Group II) : Flowering took place between 112-119 days (Second week of November)

Late flowering type (Group III): Flowering took place between 127-135 days (Fourth week of November)

Very late flowering type (Group IV) : Flowering took place between 148-170 days (Third week of December)

Observations on different growth and yield parameters over 110 genetic lines show high level of variation between and within the group (Table 6).

Varietal evaluation

Seven promising strains of lablab bean were sown in replicated plots along with the standard check (Bundel Sem-1) for their evaluation in respect to fodder as well as seed production. Strains showed high variation in seed yield ranging between 8.9 to 21.7 q/ha . Highest seed yield was obtained from LP-S-2 (21.7 q/ha) followed by S-27 (20.4 q/ha), Bundel Sem-1(19.6 q/ha) and JLP-3(17.2 q/ha). It shows that only two of the strains namely LP-S-2 and S-27 were superior over check by a margin over 10.7 and 4.7 percent.

Raising of the hybrids (F_1)

Seeds of the three crosses (F_1) obtained during the previous season were raised in spaced planting along with the parents. Observations were recorded on morphological characters, vigour of the plant and seeds attributes . Bulk seeds of the individual cross have been harvested separately.

PI-4 : BREEDING SUPERIOR VARIETIES OF PASTURE SPECIES FOR YIELD AND PERSISTENCE

4.1 Varietal Improvement for yield and quality in range grasses

(U.S.Mishra and D.S.Katiyar)

Evaluation of somaclonal variants

Twenty nine somaclonal variants (S.V.) of *Dichanthium annulatum,* raised through

Table 6 : Plant growth and yield parameters in 110 genetic lines of lablab bean

S. No.	Characteristics		GROUP-I 4 Nos (Early-maturity)	GROUP-II 46 Nos (Medium maturity)	GROUP-III 36 Nos (Late maturity)	GROUP-IV 24 Nos (Very late maturity)
1.	Days to 50% flowering	Range	73.0-78.0	112.0-119.0	127.0-136.0	148.0-170.0
		Mean	74.0	116.2	133.0	159.0
2.	Plant length (cm)	Range	108.0-236.1	94.2-165.0	90.4-174.1	129.2-210.0
		Mean	126.4	113.6	127.8	151.4
3.	No. of branches per pl.	Range	4.6-7.2	6.4-12.4	7.8-14.2	6.2-10.3
		Mean	5.2	9.7	9.9	7.2
4.	No.of nodes per plant	Range	12.4-18.3	14.6-23.4	11.4-19.4	9.4-17.6
		Mean	14.6	18.9	17.4	15.2
5.	Leafiness (%)	Range	42.0-48.0	36.0-45.0	39.0-44.0	43.0-46.0
		Mean	44.6	42.0	40.2	38.6
6.	Green fodder per plant (kg)	Range	0.60-0.95	0.50-1.50	0.7-1.72	0.85-1.30
		Mean	0.75	1.04	0.92	0.84
7.	Dry matter in fodder (%)	Range	21.0-28.0	24.0-32.0	27.0-34.0	26.0-42.0
		Mean	23.6	27.9	31.3	34.8
8.	No.of pods per plant	Range	32.0-64.0	37.0-82.0	24.0-66.0	13.0-37.0
		Mean	42.0	58.4	46.0	21.4
9.	Pod length (cm)	Range	8.4-11.6	4.2-5.8	4.4-5.6	6.8-13.7
		Mean	9.2	4.7	4.8	9.7
10.	Pod width (cm)	Range	1.4-1.9	1.8-2.4	2.0-2.6	2.1-3.8
		Mean	1.6	2.0	2.3	3.2
11.	No.of seeds per pod	Range	4.4-8.4	3.6-5.3	4.1-5.2	6.4-10.4
		Mean	5.6	4.3	4.2	8.9
12.	100 seeds weight (g)	Range	16.4-18.8	17.6-24.1	18.3-22.8	14.6-23.7
		Mean	16.8	20.4	22.0	18.4
13.	Seed yield per plant (g)	Range	20.4-43.0	24.8-85.0	19.4-64.3	19.6-57.4
		Mean	37.4	56.6	49.8	28.7

seed during 1994 along with the parental line, were evaluated for yield and associated characters and CP %. A wide range of variation was observed for all the characters. Most of the S.V. were superior to the parental line. It was also observed that all the plants of parental lines were heavily infested by disease in the month of November while no disease infestation was observed in somaclonal variants. The most desirable variants *viz.,* S.V. 7, 11, 21, 26 and 28 were selected for further testing.

Station trial

Eight promising selections of *C. ciliaris* along with IGFRI-3108, used as check, were evaluated in the 4th year. Wide range of variation was observed for all the characters studied .

Selection IGFRI-675 ranked first in both green and dry matter production which was followed by IGFRI-3133 for green and IGFRI-673 for dry matter production.

Coordinated trials under AICRP on forage crops

Dichanthium *:* Nine entries of *Dichanthium,* planted in 1993 were evaluated for IIIrd year for yield and yield contributing characters. Entry IGFRI-1981 produced significantly high green fodder yield (210.3 q/ha) and dry matter yield (77.2 q/ha) followed by IGFRI-585-1(203.9 q/ha green fodder yield and 74.0 q/ha dry matter yield).

In the average of cumulative yield for three years, IGFRI-1981 showed superiority by producing 169.0 q/ha green and 60.0 q/ha dry forage.

Cenchrus **:** Eleven promising strains of *C.ciliaris* along with two superior checks i.e IGFRI-3108 and CAZRI-75, were evaluated in second year. Strains IGFRI-3133 and IGFRI-8-4-10 were at par in green fodder yield(258.3 q/ha), occupied first rank and showed superiority over the best check CAZRI-75 (252.8 q/ha). On dry matter yield basis, strain IGFRI-8-4-10 maintained the first rank (98.0 q/ha) which was followed by IGFRI-8-4-3 (97.5 q/ha) and IGFRI -3133 (95.4 q/ha) as against the best check (93.1 q/ha).

The cumulative analysis of green fodder yield and dry matter yield for two years (1994 & 1995) again exhibited the superiority by the strain IGFRI-3133 and IGFRI-8-4-10 and yielded 167.8 q/ha and 160.5 q/ha green fodder yield and 61.3 q/ha and 60.2 q/ha dry matter yield respectively against the check(159.3 q/ha green fodder yield and 57.5 q/ha dry matter yield.

4.3 Genetic improvement of Guinea grass (*Panicum maximum*)

(D.R.Malaviya)

Five promising lines have been entered in All India coordinated trial on Guinea grass. Our entries performed well at southern centres of AICRP (green fodder yield 900 q/ha).

Range of variation was quite high for all the morphological characters. Highest genotypic coefficient of variation (GCV)

was recorded for green fodder yield (36.63%) followed by stem diameter (28.16%). Substantial variation for crude protein percent was also noted (CV = 16.42%). In general, the lines with soft hairy leaves and hairy lemma were better for crude protein (7.50%). The lines resembling *Hamil* and *Makuni* were poor in quality (CP = 5.88%).

PI-5 : CYTOGENETIC STUDIES IN FORAGE AND PASTURE SPECIES

5.1 Cytogenetical studies in cultivated legumes

(S.N.Tripathi)

Meiotic studies in induced tetraploids of *Medicago* species

Medicago littoralis (2n=4x=32) : Meiotic studies in C_1 plants revealed formation of bivalents, univalents along with multivalents of metaphase -I . Quadrivalents ranged from 1-3 with 2.28 per cell, trivalent and bivalents ranged from 0-1;1-11 with 0.047 and 9.66 per cell respectively. Formation of univalents ranged from 1-5 with 0.3 per cell. Maximum number of three quadrivalents were recorded in 52.38 percent of PMCs. Whereas, formation of trivalent was noticed in 4.76 percent of PMCs. Maximum number of bivalents (11) were registered in 19.04 percent of cells. During anaphase -I, lagging Chromosomes (1-3) were recorded in 22.5 percent of meiocytes.

Reduction in number of stainable pollen grains per unit area of microscopic field (as compared to C_0 plant) was noticed. The pollen fertility percentage was 61.5.

Medicago orbicularis (2n=4x=32) : Chromosomal associations at metaphase-I in C_2 plants showed PMCs with varying number of quadrivalents, trivalents, bivalents and univalents . Quadrivalents ranged from 1-2 with 1.10 per cell. Trivalent and bivalents ranged from 0-1,11-14 with 0.05 and 12.89 per cell respectively. 5.08 percent of meiocytes exhibited formation of trivalent. Maximum number of bivalents (14 II's) was recorded in 37.28 percent of cells. Delayed separation of one bivalent was noticed in 4.2 percent of cells. At anaphase -I, 63.3 percent of cells showed normal separation of chromosomes. However, unequal separation of chromosomes (15:17) and (13:19) were recorded in 23.3 and 13.4 percent of cells respectively. Pollen fertility percentage was 58.5.

Medicago rotata : Studies on chromosomal associations at metaphase-I in C_2 plants revealed formation of hexavalent, pentavalent, quadrivalent, bivalent and Univalent. Formation of hexavalent at metaphase-I ranged from 0-1 with 0.75 per cell and pentavalent ranged from 0-1 with 0.025 per cell. The other multivalents viz; quadrivalent and trivalent ranged from 0-1;0-1 with 0.81 and 0.1 per cell respectively. Formation of bivalents and univalents ranged from 1-14;1-4 with 12.8 and 1.3 per cell respectively. Maximum number of bivalents (14 II's) was observed in 50 percent of cells. At anaphase-I, 56.5 percent of cells exhibited normal separation of chromosomes. Appearance of two laggards registered in 18.5 percent

of cells while 12.5 percent cells exhibited 3 laggards.

Delayed separation of one bivalent was noticed in 3.5 percent of cells. Pollen fertility percentage was 54.0.

In general, the colchicine induced tetraploids of these *Medicago* species were associated with broader leaves, bigger flowers and seeds. Increase in the size of stainable pollen grains was recorded as most constant feature. The lagging Chromosomes were either lost during advanced meiotic cell division or they may form micronuclei.

Somatic chromosome complements of trispecific hybrid

Seeds obtained from F_5 plants of the trispecific hybrid, *Cajanus cajan X (Atylosia albicans X Atylosia scarabaeoides)* were sown to raise F_6 progeny.

Detailed studies of karyotype were undertaken on plant no.5-7-1.

The somatic chromosome count in the root tip cells of this plant revealed 2n=22. Individual pairs showed variability in morphological features like arm length and associated features.

5.3 Genetic manipulation of forage crop species through tissue culture studies

(M.G. Gupta, Sanjeev Gupta, Sanjay Gupta, Vishnu Bhat, B. Venkatesh Bhat and C.N. Neeraja)

In vitro regeneration and genetic manipulation studies in forage crop species were conducted in grass species and forage legumes.

Grass species

Cenchrus ciliaris : Immature inflorescence and young nodal segments were inoculated to raise calli on various combinations of nutrient media. The callus was successfully induced and grown actively on MS medium supplemented with 3 to 6 ppm 2,4-D. The actively growing calli were transferred to regeneration media to obtain the regenerating and embryogenic calli. The studies are in progress towards obtaining differentiation and regeneration of plantlets from the embryogenic calli of both the explants.

Anther culture studies were initiated on a large scale using anthers from 5 different genotypes at different developmental stages together with variation in the duration of pre-treatment at low temperature (4 to 10°C). The anthers were inoculated on N6 medium supplemented with 5 ppm 2,4-D and kept in complete darkness.

Dichanthium annulatum : Profuse induction of calli was obtained from immature inflorescence and young nodal segments on MS medium with 2 to 5 ppm 2,4-D. Development of regenerating calli, somatic embryogenesis and shoot bud organogenesis were successfully achieved at a very high frequency on subsequent transfer of the actively growing calli (raised from both the explants) to the

regenerating media. Actively growing plantlets were obtained on MS medium with 2 ppm IAA and 0.5 ppm BA, whereas, the development of plantlets on SH basal exhibited normal root development with slow growth of shoots. Direct (one step) regeneration from immature inflorescence without callus phase was obtained in several cultures. Studies are continued in this direction.

The embryogenic calli were maintained in subsequent subcultures and regeneration potential was observed in each subculture. These cultures would provide the resource material for cell suspensions and protoplast isolation, and culture for envisaged research work.

The regenerated plantlets were further grown and hardening was done to acclimatize them from culture conditions to the field conditions. Thirty *in vitro* regenerated plants were hardened which are now ready to plant in field.

Meiotic studies, conducted in the dividing PMCs of six somaclones already existing in the field, revealed the chromosome complement as 2n=40 in each case. No variation from the parent material in terms of chromosome count was observed. Zymograms for the isozymes - NADH dehydrogenase and phosphoglucomutase were developed. Variation in banding pattern for phosphoglucomutase were clearly observed among four somaclones already growing in the field. All the 29 somaclones grown in the field were observed to be free from the incidence of rust disease whereas plants raised naturally were heavily infested with rust.

Sehima nervosum* and *Heteropogon contortus : Immature inflorescence of *S. nervosum* and *H. contortus* were inoculated on various combinations of nutrient media in order to develop efficient protocol for *in vitro* regeneration in these species. Callus induction was successful in both the grass species on MS medium with 3 to 6 ppm 2,4-D.

Forage legumes

Medicago sativa : Various somatic explants such as, whole seed, hypocotyl, epicotyl and petiole segments were inoculated on various nutrient media (SH, MS and B5) with different combinations of plant growth regulators (1 to 5 ppm of 2,4-D and /or NAA and 0.2 to 0.5 ppm BI/ 6-FAP). A good response of callus induction was observed. The callus induced from the petiole was best among all from the regeneration point of view. The regeneration was obtained up to shoot bud organogenesis in the calli obtained from petiole.

Callus induction was successfully achieved from the anthers and ovaries cultured on SH/MS media with different combinations of growth regulators. While ovaries responded quite well in inducing calli both in terms of frequency and rate of callus induction (80% within 20 days), the response of callus induction from anthers was quite slow and low in frequency.

Trifolium alexandrinum : Callus induction was successfully achieved from the whole seeds, hypocotyl and epicotyl. The calli on subsequent transfer to regeneration medium exhibited rhizogenesis.

5.4 Cytogenetical approach to berseem improvement

(A.K.Roy)

Advancement of colchiploid lines and selection

C_6 and C_5 generation of colchiploids developed from twelve diploid strains of berseem were raised and rigorous selections were made on basis of morphological parameters.

Station trial

One station trial comprising 10 diploid and 10 tetraploid lines was conducted and data recorded for morphological attributes.

Results of station trial conducted in 1994-95 with 9 diploid and six tetraploid strains indicated that morphological characters and yield varied in regenerated plants after successive cuts.

Progeny evaluation

29 selected progenies along with some diploid strains were evaluated in RBD under standard agronomic and cutting schedule Some tetraploid lines *viz.,* 1-90 Q, 1-90 N-1, Comp A-1, 1-90 A-1 and 8-90 C-2 showed more than 10 % superiority for green fodder yield over Wardan.

Biochemical studies

In vivo nitrate reductase activity in tetraploids and their diploid counterparts carried out at seedling stage indicate higher activity in diploids. Inducibility of nitrate reductase activity was also studied in some selected lines of tetraploids and diploids at seedling stage. Total soluble protein level also indicate higher level in tetraploid lines.

Mutation breeding

Single plant progenies as well as bulk progenies of irradiated population of three varieties 13-90 B, 9-90 D and 5-90 M have been grown in M_2 generation.

Pollen fertility

Pollen fertility test among many tetraploid single plant progenies revealed that most of the lines have attained near 100% pollen fertility and these lines are also showing high seed set rate.

Cytological study

Some of the selected tetraploid lines were screened. They show a chromosomal constituent of 2n = 32 as against 2n =16 in diploids. Some meiotic abnormalities at anaphase as well as multivalent association at diakinensis were recorded.

Entry in coordinated trial

Two tetraploid lines have been entered in initial evaluation trial of all India coordinated trial.

DIVISION OF AGRONOMY

AG-3 : AGRONOMY OF IRRIGATED/ DRYLAND FORAGE AND PASTURE CROPS

3.1 Evaluation of varietal response of forage crops

3.1.1 Response of sorghum varieties to moisture regimes during summer under multicut system

(R.P. Singh and N.P. Shukla)

Three sorghum varieties (Bioseed 766, Proagro 94779 and Proágro 94777) with 3 moisture regimes (IW/CPE ratio of 0.5, 0.75 and 1.0) were tried in RBD. This was the second year of the experiment. Three cuts of sorghum were taken. The green forage yield ranged from 383.6 q/ha with variety Proagro 94779 to 397.5 q/ha with Proagro 94777. There was a positive effect of moisture regimes on green forage yield. The yield at IW/CPE ratio at 0.5, 0.75 and 1.0 was 335, 390.5 and 438.2 q/ ha respectively.

3.3 Cropping patterns for maximum forage production

Effect of renovation techniques and manurial schedules on guinea grass planted at different spacings

(S.N. Tripathi)

It was 3rd year of the experiment conducted on an old plantation of guinea grass established at 50, 75 and 100 cm row spacing. Treatments comprising three row spacings; three stubble renovation techniques *viz.*, shaving close to the ground, burning and untreated control and three manurial schedules consisting of 200 kg N/ha as urea; 50% N as urea and rest through FYM and 75% N through FYM and 25% as urea. Renovation methods were imposed only in the beginning of the experiment. This year only two cutting were obtained.

Among the renovation techniques, maximum forage yield of 49.1 t/ha (10.75 t DM) was recorded by stubble shaving treatment followed by stubble burning (47.4 t GM and 10.23 t DM/ha) and untreated control (41.0 t GM and 8.92 t DM/ha). Application of 75% of the total N through FYM and 25% through urea gave the highest forage yield (48.9 t GM and 10.64 t DM/ha) closely followed by 50% N as FYM and rest through urea (47.8 t GM and 10.43 t DM/ ha). Application of nitrogen through urea recorded lowest forage production (40.7 t GM and 8.84 t DM/ha). Productivity of the guinea grass increased with closer spacing. On an average 50, 75 and 100 cm inter row distance produced 48.7 t GM (10.47 t DM), 45.7 t GM (10.0 t DM) and 43.2 t GM green forage (9.43 t DM/ha) respectively.

AG-4 : SOIL AND WATER MANAGEMENT RESEARCH ON FORAGE/PASTURE CROPS

4.1 Crop water use and irrigation management

(Menhi Lal and N.P. Shukla)

Irrigation management for perennial lucerne in relation to cutting schedules and potassium levels

The investigation on perennial lucerne variety LH-84 continued in third year. Three cutting schedules (25, 35 and 45 days interval), 3 irrigation regimes - IW/CPE ratio of 0.5, 0.75 and 1.0 with 60 mm water at each scheduling) and 3 potassium levels (0, 60 and 120 of K_2O/ha) were imposed.

During November to June, the green forage yield of lucerne was significantly highest with cutting interval of 35 days (648.5 q/ha) as compared to 25 days cutting interval (453.1 q/ha). Cutting at 45 days interval yielded 581.1 q/ha of green forage.

The highest green forage yield of 572.6 q/ha was recorded with irrigation at IW/CPE ratio of 1.0. However, irrigation at IW/CPE ratio of 0.75 also produced green forage yield of 562.3 q/ha. The lowest yield was at IW/CPE ratio of 0.5 (547.8 q/ha). Application of 60 kg K_2O/ha produced the highest green forage yield of 578.1 q/ha.

During the period July to October, the cutting schedules of 25, 35 and 45 days interval produced green forage yield of 198.4, 202.3 and 248.0 q/ha, respectively.

The crop irrigated at IW/CPE ratio of 0.75 up to premonsoon months produced green forage yield of 224.8 q/ha closely followed by IW/CPE ratio of 0.5 (221.7 q/ha) during rainy season. Potassium nutrition at 60 and 120 kg K_2O/ha gave green forage yield of 221.5 and 220.5 q/ha against 206.7 q/ha under control treatment.

The total forage yield per annum was the highest with 35 days cutting interval (850.9 q/ha) followed by 45 days cutting interval (828.8 q/ha). The lowest yield occurred with frequent cutting at 25 days interval due to its deleterious effect on crop persistency in rainy season.

The irrigation at IW/CPE ratio of 0.75 resulted in the highest green forage yield of 814.9 q/ha. Irrigation at IW/CPE ratio of 0.5 and 1.0 produced forage yield of 769.2 and 777.3 q/ha respectively. Application of 60 kg K_2O/ha produced green forage of 802.1 q/ha against 789.2 q/ha without potassium nutrition.

Therefore, the cutting schedule for perennial lucerne should be at an interval of 35 days for higher forage yield and better stand longevity and the crop needs to be irrigated at IW/CPE ratio of 0.75 with 60 mm watered at each scheduling to provide suitable soil moisture environment from winter to summer months. Annual application of 60 kg K_2O/ha appears to be adequate for quick regeneration, greater productivity and persistency of lucerne crop.

4.4 Sesbania alley based fodder-food cropping system under upland and lowland soil conditions

(N.P. Shukla and A. Rekib)

Sorghum-Gram sequence in *Sesbania sesban* alley with different irrigation schedules

Gram (Radhe)

The trial was repeated for the third year in the same layout of sesbania alleys (4 treatments, no alley and alley at 4, 6 and 8 m apart) with three moisture regimes (no irrigation, one irrigation at branching and two irrigations at branching and pod formation stages).

Effect of alley width

Alley width of sesbania significantly influenced the grain and straw (*bhusa*) yield and grain weight/plant. The highest grain (20.0 q/ha), *bhusa* (16.5 q/ha) and grain weight/plant (26.9 g) recorded in case of pure gram (without alley) which were significantly superior over all the alley width treatments. Among alleys, increasing number of alley rows over no alley decreased the grain and straw yield but they were statistically at par. Plant population per unit area, number of grain per plant and plant height was not influenced significantly due to alley width treatments.

Effect of moisture regimes

Increasing levels of soil moisture gradually increased the grain and straw yield significantly, with the result that highest grain (20.5 q/ha) and straw (20.1 q/ha) yield was obtained with 2 irrigations (at tillering and pod formation stages). The number of grain per plant, grain weight per plant and plant height also increased significantly with successive increase in the moisture regimes.

Sesbania sesban

From July 1994 to June 1995 six cuts were taken. During third year the plants cut at the full growth of sorghum showed necrosis in upper parts of some plants due to smothering effect and lack of sunshine. After harvest of sorghum the plants regained their growth with fresh twig from the lower part of plants. The highest green fodder (1360 q/ha) and dry matter (365 q/ha) was obtained in case of 4 m apart alleys followed by 6 m apart alleys (952 q green and 265 q DM/ha). The lowest yield of 874 q green and 238 q DM/ha was observed at 8 m apart alleys. It was because the number of Sesbania rows decreased due to increase in alley distance which caused reduction in plant number and yield.

Total forage yield

The total forage yield of sesbania + sorghum was highest (1561 q green and 416 q DM/ha) at 4 m apart alleys followed by 6 m alleys (1176 q green and 318 q DM/ha) and 8 m apart alleys (1106 q green and 294 q DM/ha). All these alley cropping produced forage yield many times higher than the pure sorghum (261 q green and 65.5 q DM/ha) yield.

Berseem - Maize sequence in sesbania alley with phosphate and irrigation levels

Berseem

This was the 2nd season of this crop. Berseem was sown after maize (grain) on November 1994. Daily cutting of green fodder as per the requirement of animal trial was done. In all, 4 cuttings were taken and the results are summarized on the basis of total of all the cuts.

Effect of sulphur levels

Result reveals that each increasing level of sulphur increased the yield significantly from 0 to 60 kg S/ha both in case of green as well as dry matter out-turn. The per cent increase in green fodder and dry matter yield due to 20, 40 and 60 kg S/ ha over control (523.6 q green and 60.9 q DM/ha) was to the tune of 8.4, 17.5 and 22.9% for green fodder and 14.0, 22.3 and 30.2% for dry matter, respectively.

Effect of phosphorus levels

The green forage and dry matter yield increased significantly with increase in level of phosphorus from 40 kg P_2O_5/ha increased the green forage yield (610 q/ ha) significantly, but the dry matter out-turn (73.3 q/ha) was not sufficient.

AG-6 : AGROCLIMATOLOGICAL APPROACH FOR OPTIMIZING FORAGE PRODUCTION

6.1 Agroclimatology of Bundelkhand region in relation to forage crop planning

(J.B. Singh)

To find out possible shift/change in rainfall characteristics in relation to start, end and length of rainy season, thirty years rainfall data of Jhansi (1965-94) on decadal basis for three decades (i.e. 1965-74, 75-84 and 85-94) was investigated.

A type of new dimensional axiomatics can be perceived regarding early week, late week and mean week of start of rainy season during last three decades. Recent decade (1985-94) gives us light regarding early, late and mean starting time of rainy season i.e. 25th standard meteorological week (June 18-24), 29th week (July 16-22) and 27th week (July 2-8). Decadal shifting in starting time of rainy season is observed from 23rd to 25th week and 26th to 27th week against early and normal conditions respectively, whereas in case of late start there was no change. For the end of rainy season, the early, late and mean weeks correspond to 34th week (Aug. 20-26), 42nd week and 37th week (Sept. 10-16) respectively during recent decade. Further, in case of normal conditions, the end of rainy season has decreased by one week during recent two decades (Fig. 3) as compared to first decade (1965-74). The mean length of rainy season exhibits a decreasing (Fig. 3) trend (one week/decade) i.e. from 12th week to 10th week in the light of decade (1965-74) through decade III (1985-94).

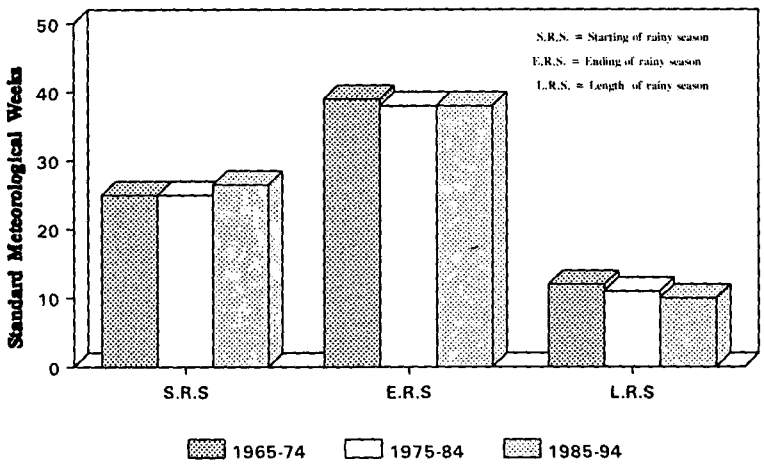


Fig. 3 : Decadal change in the characteristics of rainy season for Jhansi

A week delay in onset and also an early cessation of rains by one week in each decade suggested, thereby, a less growing period of crops over the decades. This reduced duration of rainy season, will affect the production of traditional *kharif* crop in the region. Therefore, an alternative approach based on short growing period of crop is required for successful crop production in rainfed areas of Bundelkhand region.

AG-7 : DEVELOPMENT OF AN EFFICIENT STYLO SEED GRADER

(P.K. Pathak)

The existing oil seed grader was tested for stylo-seed cleaning and grading. The capacity of machine varied between 184.56 kg/h to 330.65 kg/h for farmer's sample and 110.90 kg/h to 258.46 kg/h for SRRS, Dharwad sample. The purity of seed varied between 43.90 and 57.28 for farmer's sample and 44.00 to 63.64% for Dharwad sample. In order to increase the purity of seed by grader, the material of Dharwad collected in seed outlet and under size outlet was fed to the hopper. The purity of seed was, thus, increased to 83.58% for an effective capacity of 103.43 kg/h. This effective capacity saves about 54.46% time in cleaning as compared to manual sieving. The % material collected in blower outlet and % seed loss through the blower depended on blower speed described as below :

i) Farmer's sample
% material out in blower outlet
Y = 0.0379 x - 15.0093, r = 95.79%
% seed loss through blower outlet
Y = 0.0246 x - 17.3058, r = 93.04%

ii) RRS, Dharwad sample
% material out in blower outlet
Y = 0.0305 x - 4.5349, r = 90.54%
% seed loss
Y = 0.0358 x - 25.4366, r = 93.51%

DIVISION OF GRASSLAND MANAGEMENT

GM-1 : GEOMORPHOLOGICAL AND GRAZING RESOURCES INVENTORY OF THE LOWER SIND CATCHMENT

(J.P. Singh and Dipankar Saha)

In the second year, ground truth rate related to land form and vegetation were collected and interpreted for land form-vegetation cover relationships. The nine major land forms were finalized on the basis of secondary and field inventory data difference in terms of geomorphological features *viz.*, physiography, relief and structure. Land cover units are mentioned in table 7. The table 8 describes the vegetational details according to land form type and slope gradients. The rangelands show moderate to heavily degraded stages of vegetation which varies in composition, density and distribution according to land form and slope gradients. Reseeding of *Sehima* and *Chrysopogon* on rocky surfaces, hills and pediments and *Dichanthium* - *Cynodon* in plains, ravines and river valleys would improve the natural vegetation.

GM-2 : EXPLORATION, EVALUATION AND MAINTENANCE OF NON-CONVENTIONAL AND UNDER-UTILIZED SPECIES

(J.N. Gupta and J.P. Singh)

Various under-utilized species were evaluated for different habitat conditions

Table 7 : Major land use units of the Lower Sind Catchment (Pahuj Sub-catchment)

	Land use units*	Area in (ha)	Area in (%)
1.	Total Geographical Area	358344.00	100.00
2.	Total *rabi* Cropped Area	134563.00	37.551
3.	Total Forest Area	18362.00	5.179
4.	Total Grassland (Including degraded rangelands)	168627.00	47.037
5.	Total Ravines & Gully affected land	30825.00	8.602
6.	Water Bodies	1742.00	0.486
7.	Built up Area	4105.00	1.145

* Based on visual interpretation of satellite imageries (IRS-1B, LISS-I, FCC, Row 49 & 50, Path 27, Band-2, 3 & 4 dated 5 Feb. 95) and field verification.

Table 8 : Land form-vegetation cover relationships in the lower Sind catchment

Pahuj Sub Catchment:

Land-forms	Slope Category/ Slope (%)	Vegetation (IVI)			
		Grasses	Legumes	Shrubs	Trees
Hilly area	Xe,E,D,C,Fr (>45%)	Ergostris, Chrysopogon	Indigofera Tephrosea	Carissa Zizyphus	Acacia
Upland dessicted plateau	B,C (15-30%)	Cynodon Aristida Heteropogon	Atylosia Indigofera Tephrosea	Carissa	Acacia
Monadrocks	B,C,E (15-45%)	Iseilema Apluda Cenchrus	Tephrosea Indigofera Atylosia	Carissa Adhatoda	Acacia
Pediments	C,B (15-30%)	Cynodon Aristida Heteropogon	Atylosia Indigofera Tephrosea	Flacortia Carissa zizyphus	Acacia
Undulating terrain	B,A,R (10-35%)	Chrysopogon Aristida Cynodon Iseilema	Indigofera Atylosia Tephrosea		Acacia
Rocky surface	B,C,A (0-8%)	Heteropogon Aristida Chrysopogon	Tephrosea Atylosia	Acacia	
Gentle slopping plain	A,F (up to 5%) Dichanthium	Iseilema Cynodon	Tephrosea Indigofera	Carrisa Zizyphus	Acacia
Ravines & Gully	Xe,C,D,Fr. (10-30%) Cenchrus	Cynodon Dicanthium	Indigofera	Flacortia	Acacia
River Valley	A,F,	Iseilema Cynodon Bracharia	Tephrosea	Zizyphus Lantana	Acacia

viz., Atriplex spp. and *Chloris* spp. for saline soils, *Ipomaea aquatica, Arachis* spp. and Aleman grass for wetlands, forage groundnuts, *Canavalia* spp. *Boerhavia diffusa, Macrotyloma* for rangelands, indigenous shrub species for lean period browsing and *Simarauba glauca* (Paradise tree) for multiple uses.

Species for saline soils

In two year old plants of *Atriplex nummularia,* plant height ranged from 36.6 to 49.5 cm with 13 to 17 branches. In *A. amnicola* plant height ranged from 39.0 to 51.6 with 15 to 19 branches. The annual *Atriplex viz., A. spongiosa* flowered within 75 days after sowing and produced large number of seeds.

Species for wetlands

Two collections of *Ipomoea aquatica*, one from Calcutta and another local selection were grown under waterlogged conditions as well as in moist field. Seed production was higher in the moist field but green forage yield was higher under waterlogged conditions. A stoloniferous perennial grass *viz., Echinochloa polystachya* (Aleman grass) from Africa, produced 12 t/ha green forage in three months growth. Out of 10 accessions of *Arachis* evaluated for shade tolerance, maximum forage yield (5.4 t/ha) was recorded from IFL 2273 followed by IFL 6819 and IFL 6821 recording the forage yield of 1.46 and 1.31 t/ha, respectively.

Species for rangelands

Canavalia virosa, *Macrotyloma axillare*, *Arachis hagenbeckii* and *A. glabrata* performed better than other under-utilized species. In red gravelly soils established sward of *A. hagenbeckii* and *A. glabrata* gave the green forage yield of 34 and 29 t/ha, respectively in two cuts under rainfed condition.

Browse species

Indigenous fodder shrubs *viz., Ehretiai aspera*, *Grewia flavescens Gymnosporia spinosa*, *Helicteres isora*, *Seurinega virosa*, *Flacourtia* sp. and *Calliandra* sp. were planted.

GM-3 : RESTORATION OF DEGRADED RANGELANDS AT C.R. FARM

(J.N. Gupta, S.K. Soam and Shivnath Ram)

The programme of restoration involved the packages, reseeding of grasses and legumes in the natural grassland and the establishment of pasture after soil working in a part of the degraded rangeland.

The reseeding was done with single species as well as species mixture. The pelleted and non-pelleted seeds of three grasses *viz., Pennisetum pedicellatum*, *Dichanthium annulatum*, *Pennisetum* trispecific hybrid were broadcasted in separate plots. The pre-treated mixture of seven legumes *viz., Atylosia scarabeaoides*, *Alysicarpus rugousus*, *Macroptelium atropurpureum*, *Stylosanthes hamata*, *Rhynchosia minima*,*Centrosema pubescens*, *Mimosa invisa* was broadcasted in a separate plot.

The seeding of pelleted seed in all grasses was found better. Among a range of seven legumes, the performance of *Mimosa invisa* was best in terms of plant density and distribution. This was closely followed by *Macroptelium atropurpureum*,

Stylosanthes hamata and *Atylosia scarabaeoides* (Table 9).

The pasture establishment had three treatments *viz.*, grass : legume line sowing

Table 9 : Density and distribution of grasses and legumes in reseeded grassland

Species	Density (thousand plants/ha)	Distribution (Mc Ginnies Index)*
Grasses		
Perennial Dinanath (*Pennisetum pedicellatum*)		
Pelleted seeds	35	0.50
Non pelleted seeds	31	2.58
Marvel grass (*Dichanthium annulatum*)		
Pelleted seeds	18	0.95
Non pelleted seeds	14	2.02
Trisankar (*Pennisetum* trispecific hybrid)		
Pelleted seeds	17	0.70
Non pelleted seeds	12	1.73
Legumes		
Ban Kulthi (*Atylosia scarabaeoides*)	12	1.32
Shevri (*Alysicarpus rugosus*)	06	1.17
Siratro (*Macroptelium atropurpureum*)	16	1.33
Caribbean stylo (*Stylosanthes hamata*)	15	1.63
Rhynchosia (*Rhynchosia minima*)	03	0.83
Centro (*Centrosema pubescens*)	05	0.93
Invisa (*Mimosa invisa*)	20	1.66

* Mc Ginnies Index : (D/d) Ratio of observed density (D) and expected density (d) indicates regular distribution when < 1, sparse distribution when > 1 and aggregation when > 2.

at 50 cm row to row spacing, grass : legume line sowing at 100 cm row to row spacing, and grass at 100 cm row to row spacing and broadcasting of legume. First treatment was found best in terms of plant population and dry matter yield (Table 10).

Table 10 : Plant population (000/ha) and dry matter yield (t/ha) of grass-legume mixed pasture as influenced by method of sowing and spacing

Treatments	Grasses		Legumes	
	Plant population	Dry matter	Plant population	Dry matter
	Panicum maximum		*Stylosanthes scabra*	
T_1	28	5.32	170	1.27
T_2	15	3.59	120	0.82
T_3	15	3.22	90	0.71
CD at 5%	1.98	1.01	15.8	0.16
	Chloris gayana		*Stylosanthes scabra*	
T_1	26	3.24	180	1.30
T_2	14	1.87	140	0.92
T_3	13	1.58	110	0.78
CD at 5%	2.61	0.98	21.3	0.21

T_1 = Grass : Legume line sowing at 50 cm row to row spacing.
T_2 = Grass : Legume line sowing at 100 cm row to row spacing.
T_3= Line sowing of grass at 100 cm row to row distance and broadcasting of legume.Forage yield, water use efficiency and ET of berseem at different cuttings.

GM-4 : MANAGEMENT OF SHRUB INFESTED GRASSLAND THROUGH MIXED HERD GRAZING

(J.P. Singh, Vinod Shankar and V.S. Upadhyay)

In the first year of this experiment mixed herd i.e. cattle, sheep and goats grazing was introduced in 6 ha area of natural grassland infested with woody perennials. The animal wise grazing/browsing preferences are shown in Fig. 4, 5 and 6 and the trends are described below :

Cattle

In the monsoon period, grazing cattle devoted maximum percentage of grazing time to grasses. Annual grasses were

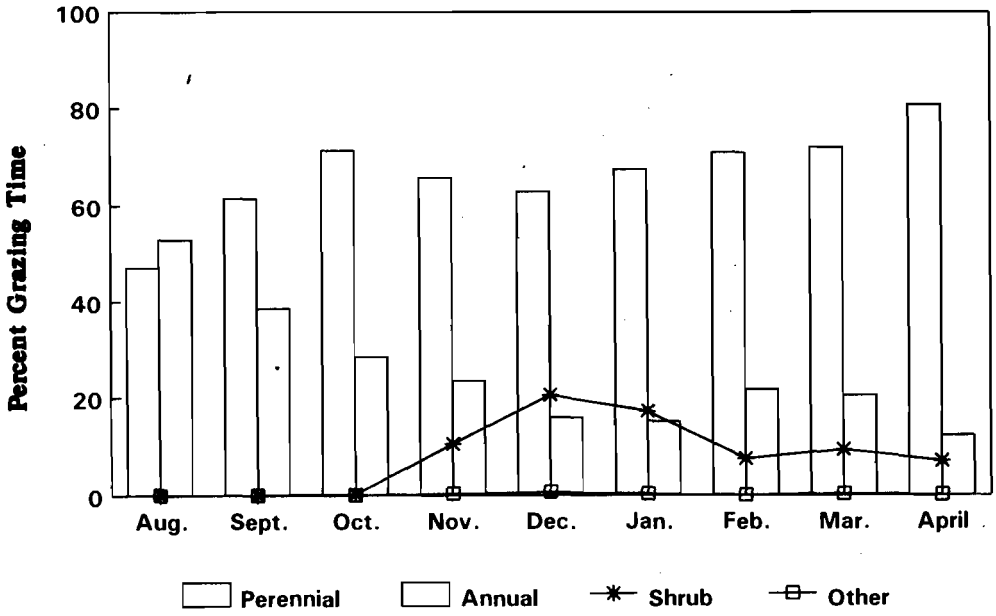


Fig. 4 : Grazing preference of cattle

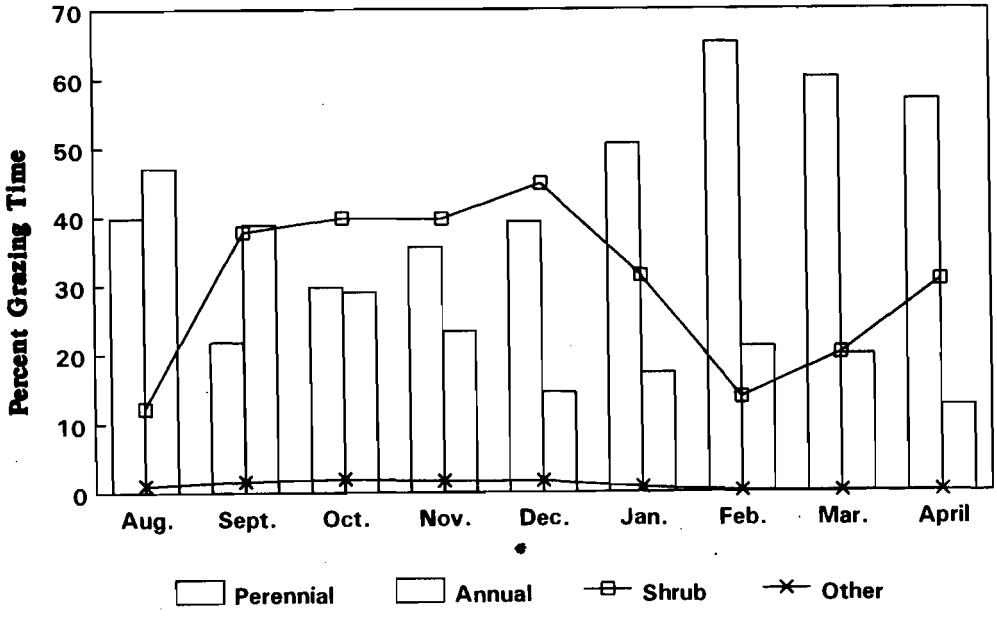


Fig. 5 : Grazing preference of sheep

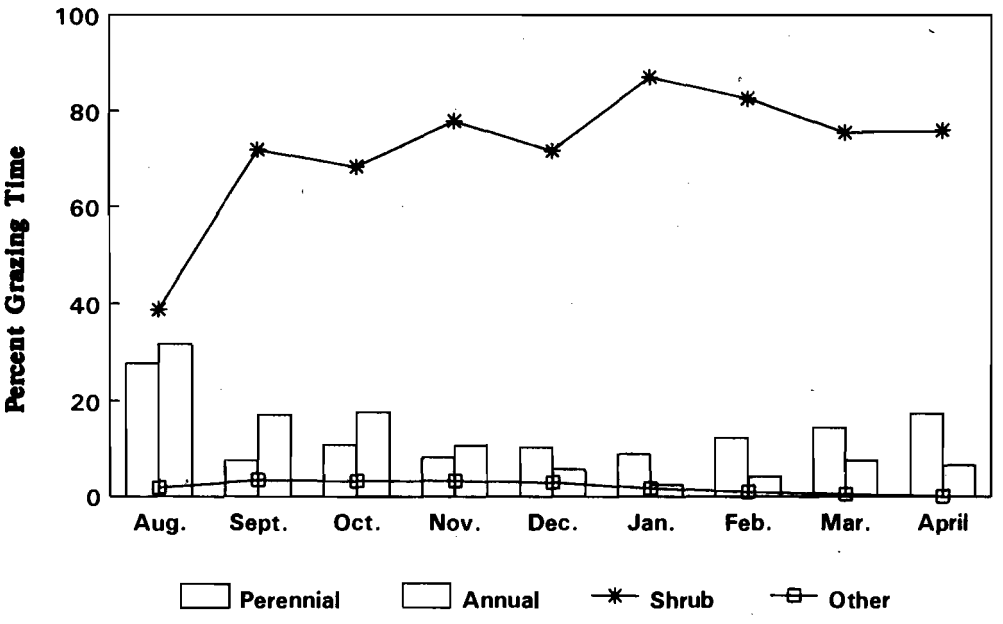


Fig. 6 : Grazing preference of goat

preferred to perennial grasses i.e. *Heteropogon contortus Sehima nervosum, Dichanthium annulatum, Iseilema laxum,* etc. *Heteropogon contortus* at young stage was the most preferred grass. From November onwards cattle started browsing the shrubs. *Securinega virosa, Grewia flavescens* were the most preferred followed by *Acacia catechu, Zizyphus xylopyrus* which were browsed much in January and February. *Flacourtia indica* and *Helicteres isora* were browsed in January and *Ehretia aspera* in February.

Sheep

In monsoon period, sheep also showed higher preference to annual grasses. *Heteropogon contortus* and *Sehima nervosum* among perennial grasses were grazed in preference. Among shrubs *Zizyphus xylopyrus, Acacia catechu, Flacourtia indica* were browsed much followed by *Z. xylopyrus, Acacia catechu, Securinga virosa, Carissa spimarum, Grewia flavescens, Ehretia aspera.* In February, dry perennial grasses were more preferred than shrubs.

Goats

At the start of grazing in monsoon period goats also devoted maximum grazing time to annual grasses. From September onwards goat spent more time to browse the shrubs. *Zizyphus xylopyrus, Z. nummularia, Acacia catechu* were the most preferred shrubs followed by *Securinega virosa, Grewia flavescens, Flacourtia indica, Carissa sprinarum* etc. *Ehretia aspera* was browsed from December onwards. Among grasses

Heteropogon contortus, *Dichanthium annulatum*, *Sehima nervosum*, were preferred. It was interesting to note that weeds (*Lelosia argentea*, *Sida* spp., *Tephrosia purpurea*, *Peristrophe bicalycalata*), perennial climbers *viz.*, *Rivea hypocrateriforms*, *Cocculus hirsutus*, *Gymnema sylvestre* and non-palatable shrubs *viz.*, *Lantana camara*, *Calotropis procora* were grazed maximum by the goats.

GM-5 : IDENTIFICATION OF FACTORS RESPONSIBLE FOR FORMATION OF PURE SEEDS IN RANGE/CULTIVATED GRASSES

(S.S. Parihar and Anjali Kak)

Studies were undertaken on IHE (Initial Head Emergence), peak inflorescence density, number of racemes/branches per panicle, time required for anthesis, anthesis to seed maturity, seed shedding and pure germinating seed (PGS) yield in the following 21 grasses.

Paniceae : *Brachiaria brizantha*, *B. decumbens*, *B. mutica*, *Paspalum notatum*, *Panicum maximum*, *P. antidotale*, *Setaria sphacelata*, *Cenchrus setigerus*, *C. ciliaris* and *Melinus minutiflora*.

Andropogoneae : *Andropogon gayanus*, *Dichanthium annulatum*, *Bothriochloa pertusa*, *B. intermedia*, *Chrysopogon fulvus*, *Heteropogon contortus*, *Vetiveria zizanioides* and *Sehima nervosum*.

Eragrosteae : *Sporobolus indicus*.

Chlorideae : *Chloris gayana* and *C. virgata*.

The IHE and peak inflorescence density of a few selected grasses were studied. IHE period and peak inflorescence density period was specific for each grass. Four grasses viz., *A. gayanus*, *B. mutica*, *M. minutiflora* and *C. gayana* flowered after 5-6 months of vegetative growth in response to short days during late November to December. Variations in seed yield components were recorded. The inflorescence density increased linearly with time. Highest inflorescence density (1145/m^2) was observed in *A. gayanus* and lowest (36/m^2) in *B. mutica*. Maximum seed yield per panicle (1.11 g) was recorded in *V. zizanioides* and minimum (0.058 g) in *A. gayanus*. Highest PGS yield was found in *V. zizanioides* (690 kg/ha) and lowest (nil) in *Chloris gayana*, although spikelet yield was 149 kg/ha.

Variations were also noticed in respect of 1000 dispersal unit (spikelet) weight, Caryopsis weight etc. Maximum weight of 1000 spikelets (filled) was recorded in *C. setigerus* (7.0532 g) followed by *B. decumbense* (6.8469 g) and *H. contortus* (5.682 g) and minimum in *M. minutiflora* (0.1575 g) followed by *C. virgata* (0.3213 g). Maximum weight of 1000 caryopsis was recorded in *P. notatum* (4.597 g) and minimum in *Sporobolus* (0.008 g).

In *Sehima nervosum* and *C. fulvus* delaying of reproductive phase by cutting management up to October-November enabled formation of higher percentage of pure seeds.

GM-7 : EVALUATION OF CYANOBACTERIA AS A PROTEIN SUPPLEMENT TO ANIMAL DIETS

(Dipankar Saha and Bandla Srinivas)

In the first phase of the five year study shallow waterlogged patches of the river Pahuj (Latitude 25°31'25" and Long 78°32'25") were surveyed for the cyanobacterial and other microalgal seasonal resource patches and gradient studies. Thirty genera under Chlorophyceae, Cyanophyceae, Bacillariophyceae and Dinophyceae were recorded (Fig. 7). This will be followed by biochemical characterization through culture, purification and isolation resulting into protein production by photobioreactors and protein utilization studies in the livestock.

GM-8 : STUDIES ON GRASS-LEGUME INTERACTION

(S.S. Parihar, Shivnath Ram and Anjali Kak)

8.1 Studies on grass-legume interference

The relative importance of above and below-ground interference was investigated by growing seven range legumes viz., *Atylosia scarabaeoides*, *Clitoria ternatea*, *Macroptelium atropurpureum* cv. *Siratro*, *Stylosanthes hamata*, *S. scabra*, *S. guianensis* and *Sesbania sesban* with three treatments in natural *Sehima-Heteropogon* grassland. The treatments were, (i) Legumes grown on bare soil (B) i.e. no competition, (ii) Legumes grown with root competition in natural grassland (C) as shoot competition prevented by clipping the shoots regularly and (iii) Legumes grown with root and shoot competition was equal in treatment 2 and 3 but shoot competition occurred only in (unclipped) tall grasses.

Reduction in the yield due to root interference (*B-C* x 100) varied from 12.73 to 57.11% and in case B of root and shoot interference (*C-T* x 100) reduction in the yields in the treatment C varied from 23.8% to 79.73%. The results of the experiment suggest that introduction of range legumes in the natural *Sehima-Heteropogon* grassland is difficult in view of above ground as well as below-ground competition.

8.2 Effect of potash on grass-legume interference and persistence of legumes in sown pasture

An experiment was conducted by establishing a mixed pasture of *Chrysopogon fulvus* and *Stylosanthes hamata* using a replacement series of experiment with five levels of interference i.e. grass and legume in monoculture and grass and legume with three combinations 1:1 (one row of grass and one row of legume) 2:1 and 1:2 with 3 levels of potash (K_0, K_{30} and K_{60} kg/ha) in a RBD factorial design. Yield advantages for intercropping as compared to monoculture and LER was higher (1.29 to 1.37) with 2 rows of grasses and one row of legume (2:1). However, potash did not have any significant effect on yield parameters,

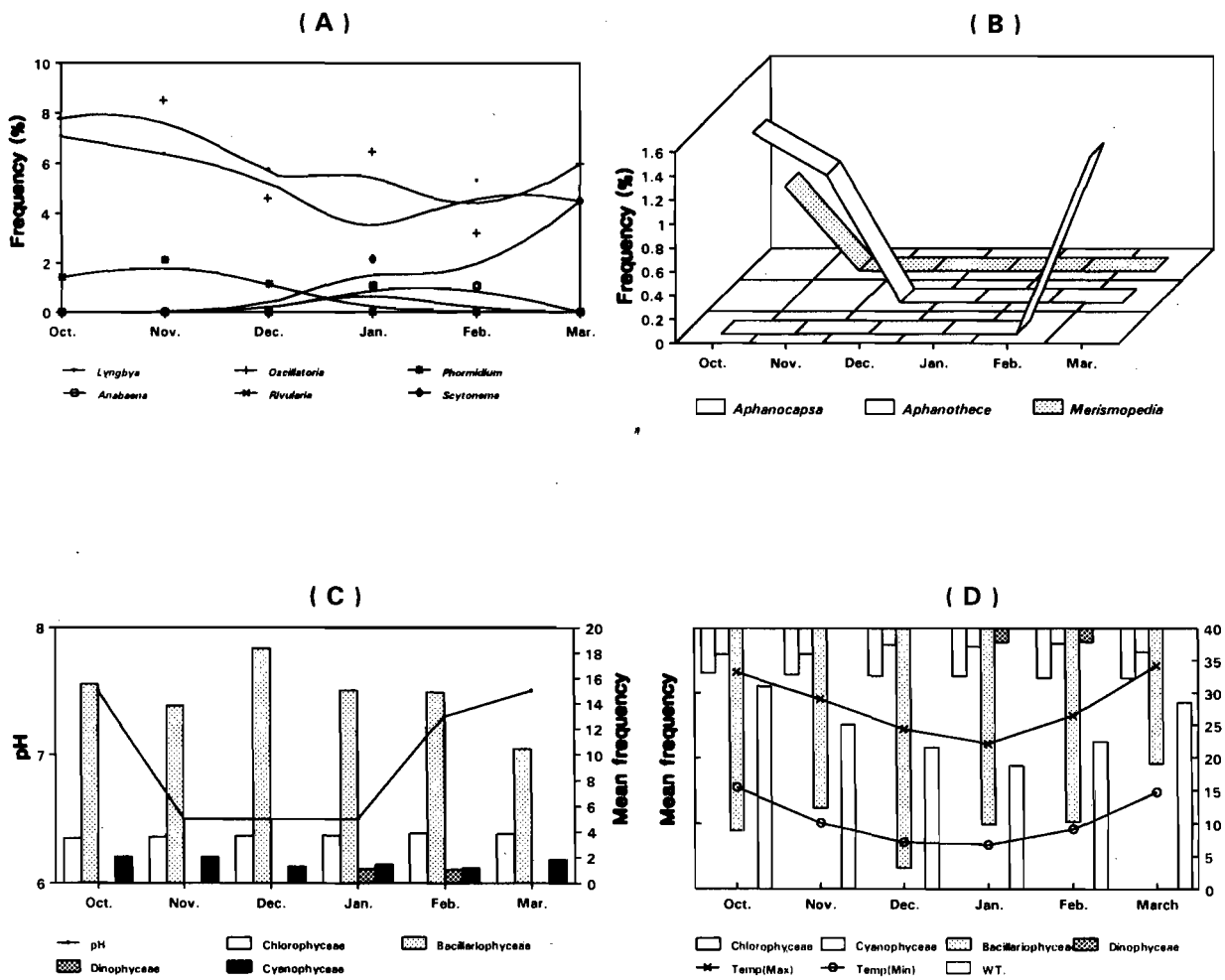


Fig. 7 : Individual species in Cyanophycean order (A) Nostocales, (B) Chroococcales and class level gradients in relation to (C) pH and (D) ambient temperature

which may be attributed to less time available for the growth of grasses and legumes in the establishment year.

8.3 Root and shoot interference studies between grasses and legumes grown in pots

Individual species of grass and legumes were raised in pots The treatments were, (i) No competition (grasses and legumes raised in separate pots) competition through roots only, (ii) Competition through shoots only and (iv) Competition through roots as well as shoots. The grasses studied were : *Heteropogon contortus* vs. *Clitoria ternatea*; *H. contortus* vs. *Siratro*; *Chrysopogon fulvus* vs. *Clitoria ternatea*; *C. fulvus* vs. *Siratro* and *C. fulvus* vs. *Sesbania*.

Both above and below-ground competitions resulted in decrease in the yield of grass as well as legume. For example, yield of *H. contortus* was reduced by 46.22% (under root and shoot competition) when grown with *Clitoria ternatea* and yield of *Clitoria* was also reduced by 49.03% with *H. contortus*. Yield reduction under root competition was about 27 to 30% in both the species. However, there was no significant effect of shoot competition on each other.

DIVISION OF AGROSILVIPASTURE

ASP-1: AUTECOLOGY OF FODDER CUM FUEL TREES/SHRUBS

1.5 Exploration, germplasm collection and evaluation of minor wild fruit trees in Bundelkhand region

(Sunil Kumar and Gulshad Mohammed)

Information pertaining to four fruit trees *viz.*, Indian goose berry (*aonla - Emblica officinalis*), custard apple (*Annona squamosa*), *Chironji* (*Buchanania lanzan*) and Indian cherry (Lasora - *Cordia myxa*) have been collected from state forest department.

ASP-2: SILVIPASTORAL STUDIES

2.2.2 Lopping management studies in selected fodder trees/shrubs in silvipastoral systems

(M.M. Roy and B.K. Choubey)

In fourth year of study on 8 year old *Dichrostachys cinerea* based silvipasture, more growth in height and collar diameter was obtained in unlopped plants (3.36 m and 1.78 cm) as compared to lopped plants (2.91 m and 1.32 cm). There was, however, not much difference in the growth of observational plants in different spacing treatments, excepting the 3 x 2 m treatment where average diameter growth was less by over 18 per cent.

Seed production was significantly low in lopped plants (0.29 - 0.49 kg/tree) as compared to unlopped plants (1.98 - 2.36 kg/tree). Higher dry matter yield was obtained in wide spaced (4 x 4 m) treatment (2.29 t/ha) as compared to narrow spaced (3 x 2m) treatment (1.38 t/ha). However, on account of higher production from sucker and lopped leaf and branch material, the 4 x 2 m spacing treatment continued to provide higher total biomass (4.67 t/ha).

ASP-4 : DEVELOPMENT OF HORTIPASTORAL SYSTEM FOR THE WASTELAND OF BUNDELKHAND REGION

4.1 Growth and productivity of fruit crop in association with grasses and legumes

(S.K. Sharma)

Fruit crops : Growth parameters *viz.* Plant height, stem diameter and tree canopy (average of north-south and east-west diameter of the tree) of jujube (*Zizyphus mauritiana* cv Gola) were maximum when trees were grown with grass (*Cenchrus ciliaris*) as compared to other treatment combinations. However, the difference in these growth parameter was statistically non significant. Maximum fruit production was recorded when the trees were grown with legume (*Stylosanthes hamata*), which was statistically higher than the control.

Pasture production : Pasture (*C. ciliaris*

and *S. hamata*) production on dry weight basis was maximum, when grass was grown with trees . However, differences were non-significant (Table 11).

Table 11 : Growth and production of jujube based hortipastoral system

Treatment combinations	Tree growth & production Pl. ht. (cm)	*CD (cm)	Canopy (cm)	Fr Yld (kg/tr)	Pasture production (DM t/ha)
Tree alone	321.39	7.28	332.22	20.48	-
Trees + Grass	354.83	8.48	385.28	17.74	5.63
Tree + Legume	340.28	7.69	372.78	25.35	4.00
Tree + Grass + Legume	314.00	7.56	374.44	22.45	4.32
CD at 5%	NS	NS	NS	3.06	NS

Pl ht = Plant height, *CD = Collar Diameter and
Fr Yld = Fruit yield

4.2 Development of Kinnow based Sehima dominated hortipastoral system

(S.K. Sharma)

Tree component : Plant height, collar diameter and tree volume were higher, when trees (Kinnow, *Citrus nobilis* x *C. deliosa*) were grown either with grass (*Sehima nervosum*) and/or legume (*Stylosanthes hamata*). However, differences were non-significant (Table 12).

Pasture component : Maximum pasture production on dry weight basis was obtained when both grass and legume were grown with Kinnow trees, however, the differences were statistically nonsignificant (Table 12).

4.3 Development of *Aonla* based Hortipastoral system

(Sudhir Kumar and R.C. Singh)

4.3.1 Performance of *Aonla* cultivars in different soil mixture under nursery condition

Plant height in each cultivars increased till 90 days after putting in the mixture, then they went to dormancy (January onward). Among different soil combinations, red soils + FYM (1:1) showed better results (49.88 cm) followed by red soil + black soil + FYM in ratio of 2:1:3 (47.44 cm) (Table 12). Interaction of variety and soil mixture also showed significant effect on the height. In red soil + FYM (1:1), maximum height increased in *Chakaiya* followed by NA-6,

Table 12 : Growth and production of Kinnow based hortipastoral system

Treatment combinations	Tree growth & production Pl. ht. (cm)	*CD (cm)	Canopy (cm)	Fr Yld (kg/tr)	Pasture production (DM t/ha)
Tree alone	140.39	4.83	5.49	66.5	-
Tree + Grass	172.44	5.07	8.76	46.17	5.48
Tree + Grass + Legume	161.50	5.16	8.87	52.33	8.87
Grass alone	-	-	-	-	4.95
CD at 5%	NS	NS	NS	NS	NS

Pl. ht = Plant height, *CD = Collar diameter, Fr Yld = Fruit yield

NA-7 and *Kanchan*. Almost same trend was found in other soil mixtures except red + black + FYM (1:1:2) where *Chakaiya* was having lowest increase in height followed by *Kanchan*, NA-6 and NA-7.

Collar diameter (cd) was also more in NA-6 (0.90 cm) followed by *Chakaiya* (0.59 cm), NA-7 (0.46 cm) and *Kanchan* (0.46 cm). Again, as in case of height, the trend was almost similar at 30, 60 and 90 days. As far as soil mixture is concerned both Red soil + FYM (1:1) and Black soil + FYM (1:1) show significantly maximum cd (0.66 cm in each case), but both were at par with each other. Next best mixture was red soil + black soil + FYM in ratio of 1:1:2 (0.62 cm) (Table 13). Interaction effect also showed the significant results. In each of the mixture, cultivar NA-6 gave maximum cd followed by *Chakaiya* almost in all the cases.

6.2 To study the distribution pattern of grass production and its relationship with tree crown area in silvipastoral system

(T.A. Khan and P.S. Pathak)

As a preliminary research activity, data pertaining to *Acacia tortilis* + *Cenchrus ciliaris* associated silvipastoral system with two spacings 4 x 3 and 4 x 4 m have been recorded. The four tree plot was divided into nine grids (Fig. 8) and in each grids data on soil moisture at 0-15, 15-30 cm depths, PAR (Photosynthetically Active Radiation) at 10.00, 11.00 and 12.00 AM together with tree growth attributes like diameter at 20, 130 cm, HAG and Canopy maximum and minimum stretch were recorded.

Attempts have been made to establish the relationship between diameter and

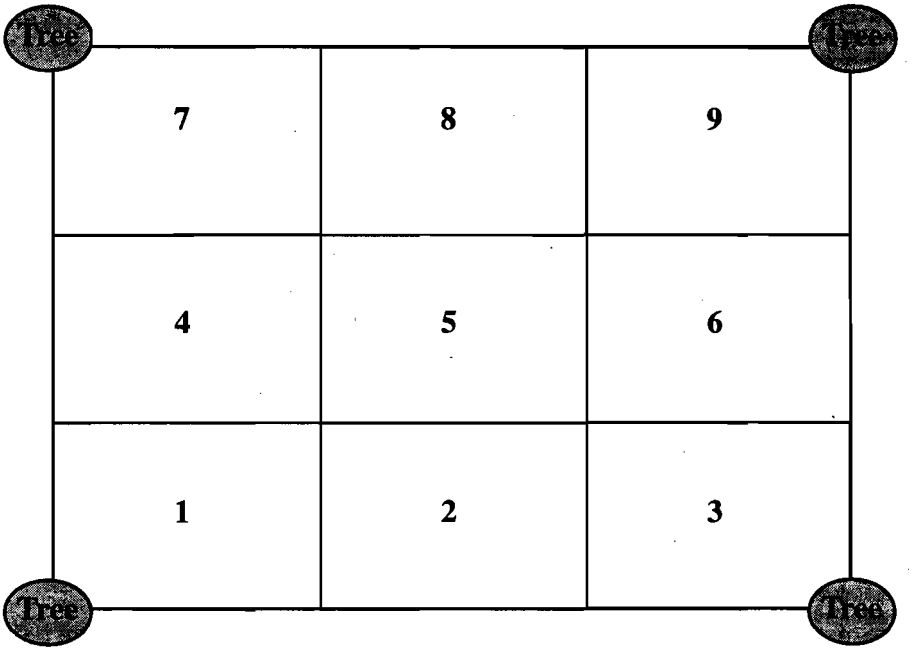


Fig. 8 : Grids within the 4 trees

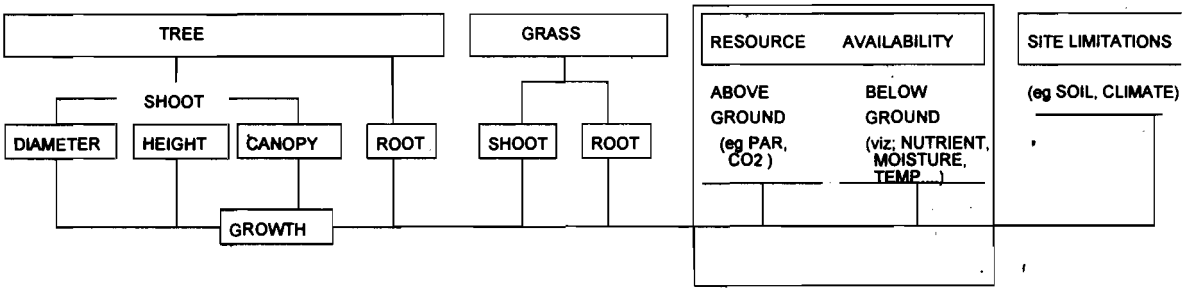


Fig. 9 : Principal component interactions in a tree grass system

Table 13 : Growth of *Aonla* cultivars in different soil mixtures under nursery condition

Treatments	Days after planting in the mixture							
	0		30		60		90	
	Ht (cm)	CD (cm)	Ht (cm)	CD (cm)	Ht (cm)	CD (cm)	Ht (cm)	CD (cm)
Variety (V)								
NA-7 (V1)	38.95	0.46	41.23	0.48	43.30	0.49	45.70	0.52
NA-6 (V2)	70.93	0.90	74.08	0.92	77.95	0.94	79.63	0.99
Chakaiya (V3)	43.65	0.59	46.38	0.61	49.05	0.63	60.55	0.66
Kanchan (V4)	29.65	0.46	31.78	0.48	33.55	0.49	35.38	0.51
SEM ±	2.28	0.04	2.19	0.06	2.24	0.04	2.08	0.05
CD at 5%	6.76	0.13	0.49	0.18	6.64	0.13	6.17	0.14
Soil Mixture (T)								
T_1	49.88	0.66	52.88	0.67	57.94	0.69	60.72	0.72
T_2	45.66	0.66	48.78	0.68	51.06	0.69	52.19	0.72
T_3	45.50	0.62	48.19	0.64	50.63	0.66	53.28	0.68
T_4	40.50	0.48	42.41	0.50	43.88	0.51	45.38	0.54
T_5	47.44	0.51	49.56	0.62	51.31	0.63	52.50	0.68
SEM ±	2.55	0.05	2.45	0.07	2.51	0.05	2.33	0.05
CD at 5%	7.56	0.14	7.26	NS	7.42	0.15	6.89	0.15

T_1 = Red soil (R) + FYM (1:1)
T_2 = Black soil (B) + FYM (1:1)
T_3 = R + B + FYM (1:1:2)
T_4 = R + B + FYM (1:2:3)
T_5 = R + B + FYM (2:1:3)

canopy area and to quantify the effects of canopy area, PAR and soil moisture on grass productivity as per flow chart illustrated in Fig. 9.

In 4 x 4 m, no significance could be detected but in 4 x 3 m, the following relationship was obtained.

Grass (Per Sqm basis) = 200.72 EXP [-0.5747**(S.M.0-15)-0.0589(S.M.15-30)-0.2133(PAR 10.00 hrs)+0.1404(PAR 11.00 hrs)+0.5366**(PAR 12.00 hrs)+0.0164 *(Canopy)] R^2=0.517, Adj. R^2=0.445

This implied that soil moisture(S.M.) at 0-15 cm depth, PAR at 12.00 hrs and canopy spread are major attributes affecting the grass productivity in *Acacia tortilis* associated silvipastoral system. Besides the above factors, soil temperature and root spread of the trees may be incorporated to have better relationships. Such relationships will enable us to formulate the decay function of under story grass productivity, can be linked with tree growth allometric functions in building the model.

DIVISION OF SOIL SCIENCE

SS-1 : SOIL STUDIES UNDER INTENSIVE FORAGE PRODUCTION

1.1.2 Soil P test crop response studies under intercropping

(S.B. Tripathi)

The field study with P levels (0, 40, 80 and 120 kg P_2O_5/ha) in low, medium and high P soil indicated that the green and dry fodder yield of sorghum and oat grown as pure and mixed with cowpea and *senji*, respectively increased considerably due to P application over control. Such increases were significant up to 120 kg P_2O_5/ha in low P soils (available P below 10 kg/ha) and up to 80 kg P_2O_5/ha in medium to high P soils (available P 11-40 kg/ha). On the basis of response equations for dry fodder the agronomic optimum dose of P for maximum production was 11.5, 92.2 and 85.5 kg/ha for sorghum; 118.5, 93.3 and 90.8 kg/ha for sorghum + cowpea; 108.4, 93.1 and 92.1 kg/ha for oat and 109.0, 105.0 and 97.2 kg/ha for oat + *senji* in low, medium and high P soils, respectively. The yield response to added P was maximum in low P soils and which decreased sharply in medium to high P soils. The mixed stand of sorghum + cowpea and oat + *senji* had highest response to added P than pure stand of sorghum and oat. As compared to control the application of 40-120 kg P_2O_5/ha in low, medium and high P soils improved P uptake by 26-40, 10-17 and 9-14 % in sorghum, 18-46, 9-16 and 8-12 % in sorghum + cowpea; 16-26, 8-17 and 7-12 % in oat and 17-31, 12-15 and 7-8 % in oat + *senji*, respectively. The average P uptake of sorghum, oat, sorghum + cowpea and oat + *senji* in control was 16.69, 19.4, 22.7 and 25.8 kg/ha in low P soils, 20.4, 21.5, 29.3 and 29.6 kg/ha in medium P soils and 22.0, 22.4, 31.4 and 32.8 kg/ha in high P soils, respectively. The content and uptake of other nutrients *viz.*, K, S and Mg in crop plants was influenced in increasing trend with an increase in P levels up to 120 kg P_2O_5/ha except S content and its uptake in medium to high P soils at 120 kg P_2O_5/ha, where it reduced considerably over lower level of P application i.e. 80 kg P_2O_5.

Pot study showed a significant effect of P application on yield and P uptake of sorghum + cowpea and oat + *senji* at 80 kg P_2O_5/ha in low to medium and at 40 kg P_2O_5/ha in high P soils. The application of 40, 80 and 120 P_2O_5 kg/ha over control improved dry fodder by 32, 49 and 56 % in low; 22, 35 and 35 % in medium and 14, 19 and 19 % in high P soils for sorghum + cowpea and 42, 68 and 73 % in low; 33, 50 and 54 % in medium and 25, 40 and 38 % in high P soils for oat + *senji*, respectively. The responses to added P in clay loam red soil were maximum followed by clayey soils (black and red and black mixed soils). For predicting economic fertilizer response the critical limit of available economic fertilizer response the critical limit of available P in soil was obtained to be 20 and 15 kg P/ha for dry fodder yield and

P uptake of oat + *senji* and sorghum + cowpea, respectively. Correlation studies between soil test methods and Bray's yield/uptake showed the superiority of Olsen's P method than Bray's and Dyer's method for available P content of soil.

1.1.3 Soil K test crop response studies under intercropping

(S.B. Tripathi)

The field experiments were conducted on sorghum and sorghum - cowpea during *kharif* season; oat and oat + *senji* during *rabi* season with four levels of K (0, 30, 60 and 90 kg K_2O/ha) and three K soils (low, medium and high). The green and dry fodder yields of both the season crops increased significantly with the application of 60 kg k_2O/ha in low and medium soils and at 30 kg K_2O/ha in high K soils over their control. The yield at 60 kg k_2O/ha in medium and at 90 kg k_2O/ha in low K soils was more or less similar to the yield obtained at 30 kg K_2O/ha in high K soils. The responses to added K were highest in low K soils and the lowest in high K soils. On the basis of response equations, the agronomic optimum dose of K was worked out to 74.6, 63.9 and 60.0 kg/ha for oat; 75.6, 67.9 and 65.5 kg/ha for oat + *senji* 72.2, 67.7. and 57.2 kg/ha for sorghum and 75.7, 70.9 and 62.1 kg/ha for sorghum + cowpea in low, medium and high K soils, respectively.

The K uptake by crops grown as pure and mixed stand was improved with the application of K over control, maximum effect being at 90 kg K_2O/ha in low to medium soils and at 60 kg K_2O/ha in high K soils. As compared to control the application of K was found in improving the position of crops nutrients (P, K, Mg and S) in all K soils except in high K soils at 90 kg K_2O/ha in case of Mg and S content as these were reduced considerably.

The study carried out in pot condition indicated the similar effect of K application on yield and nutrients uptake as achieved in field condition. The response to added K for dry fodder yield of oat + *senji* was maximum being 42-73 %, 33-54 % and 25-38 % in low, medium and high K soils than sorghum + cowpea. The response of dry fodder of sorghum + cowpea in low, medium and high K soils could be obtained to 32-56 %, 22-35 % and 14-19 % with applied K (30-90 kg K_2O/ha) over control, respectively. The correlation study with soil K test values extracted by various extractants and Bray's % yield/uptake showed the superiority of boiling 1 N HNO_3, $NaHCO_3$, H_2SO_4, 1 N $NaHCO_3$ and oxalic acid etc. The critical limit of available K in soil by ammonium acetate, HNO_3, $NaHCO_3$, H_2SO_4 and oxalic acid extractants used as soil test methods was worked out to 120, 600, 140, 475 and 650 kg/ha, respectively for better response of dry fodder yield of sorghum + cowpea to optimum fertilizer dose.

Soil fertility

As compared to initial status of K in soil the available and non exchangeable K after crop harvest improved with the

application of K and reduced in no K application-control (field study). The maximum reduction being 15-25 % was in low K soils. The % increase of available K was highest in low K soils whereas non exchangeable K in medium to high K soils. The plot under sorghum + cowpea and oat + *senji* mixed stand was superior in lowering non exchangeable K and improving readily available K content than pure stand of sorghum and high K soils was improved to the extent of 12-24, 30-46 and 31-52 % in sorghum, 17-34, 29-43 and 30-50 % in sorghum + cowpea; 6-16, 14-40 and 21-36 % in oat and 14-30, 23-42 and 24-48 % in oat + *senji* with the application of K (30-90 kg/ha) over control, respectively. Similarly, the content of available K due to its application improved to 15-29, 18-38 and 20-40 % in sorghum; 20-36, 23-39 and 24-41 % in sorghum + cowpea, 13-25, 15-29 % in oat and 19-36, 21-39 and 22-45 % in oat + *senji* plots for low, medium and high K soils, respectively. After crop harvest the control plot of sorghum, sorghum + cowpea oat and oat + *senji* had non exchangeable K content of 450, 440 and 395 and 389 kg/ha in low; 500, 495, 505 and 485 kg/ha in medium and 610, 534, 601 and 503 kg/ha in high K soils, whereas available K content of soil was 85, 88, 84 and 86 kg/ha in low 112, 115, 110 and 128 kg/ha in medium and 150, 160, 139 and 166 kg/ha in high K soils, respectively. The similar effect of K application on available and non exchangeable K content under sole and intercropping system was also observed in pot study.

1.2.1 Studies on secondary elements and micronutrients in relation to forages

(O.P.S. Panwar)

Studies on Zn and P nutrition in Alfalfa (*Medicago sativa*)

Experiment was conducted under pot culture conditions employing two different soil types : red (*Parwa*) and Black (*Kabar*). Three graded levels of Zn varying from 10-30 ppm/pot (as $ZnSO_4$) and P in a range from 20 to 60 ppm/pot (as DAP) were applied through soil application, along with control (no nutrient) in each case.

There was a consistent increase in fodder yield with each increment in the level of P fertilization. The response of P indicated 15.70-25.23% and 16.88-26.96% increase in forage yield at P_{20} to P_{60} ppm level, over and above in the control (13.75 and 16.17 g/pot) in Red and Black soil respectively. The response of Zn was observed up to Zn 10 ppm level which was almost at par with Zn 20 ppm level, beyond which it did not affect favourably.

The response of Zn resulted in an increase to the tune of 21.23 and 20.87 and 23.7 and 22.50% at Zn 10 and Zn 20 ppm level over the control, in Red and Black soil respectively. However, the maximum forage yield was obtained in a combined treatment of Zn_{10} P_{60} ppm (19.05 and 22.69 g/pot) followed by in Z_{10} P_{40} ppm (19.05 and 22.69 g/pot) followed by in Z_{10}

P_{40} ppm (17.88 and 21.30 g/ pot) in Red and Black soil respectively, which gave forage production almost at par with Zn_{20} P_{60} ppm level.

Application of P was observed to increase the contents of nutrients to the extent of 0.04-0.09% and 0.17-0.30% N, 0.01-0.03% and 0.05-0.09% P and 0.19-0.022% and 0.39-0.64% K, over control (3.10 and 2.97% N, 0.28 and 0.25% P and 2.37% and 2.19% K) in Red and Black soil respectively. Fertilization with Zn also improved contents of nutrients to the tune of 0.04-0.10% and 0.23-0.25% N and 0.20-0.24% and 0.46-0.60% K, in comparison to their contents in control, in Red and Black soil respectively. However, no definite consistent trend was observed regarding effect of Zn application on P contents in plants.

Fertilization of P increased the availability of N and P to the extent of 10.97-13.40 ppm and 18.69-22.73 ppm available N and 3.8-4.6 ppm and 2.61-4.89 ppm available P, in contrast to their status in control (109.76 ppm and 117.60 ppm and 3.95 ppm and 5.0 ppm available N and P) in red and black soil respectively. Similar increasing trend was also observed on available K status as affected by P application.

Application of Zn also increased the availability of N to the extent of 12.93 ppm and 21.56 ppm over and above its status in control in red and black soil respectively, but up to the level of Zn_{20} ppm only beyond which it didn't affect favourably and similar increasing trend was exhibited on the status of available K also in the soil. Available P increased to the tune of 4.75 ppm and 4.04 ppm over the control, in red and black soil respectively up to Zn_{10} ppm level only, beyond which it tended to be affected adversely.

1.4 Effect of leaf manuring on nutrient dynamics and soil productivity.

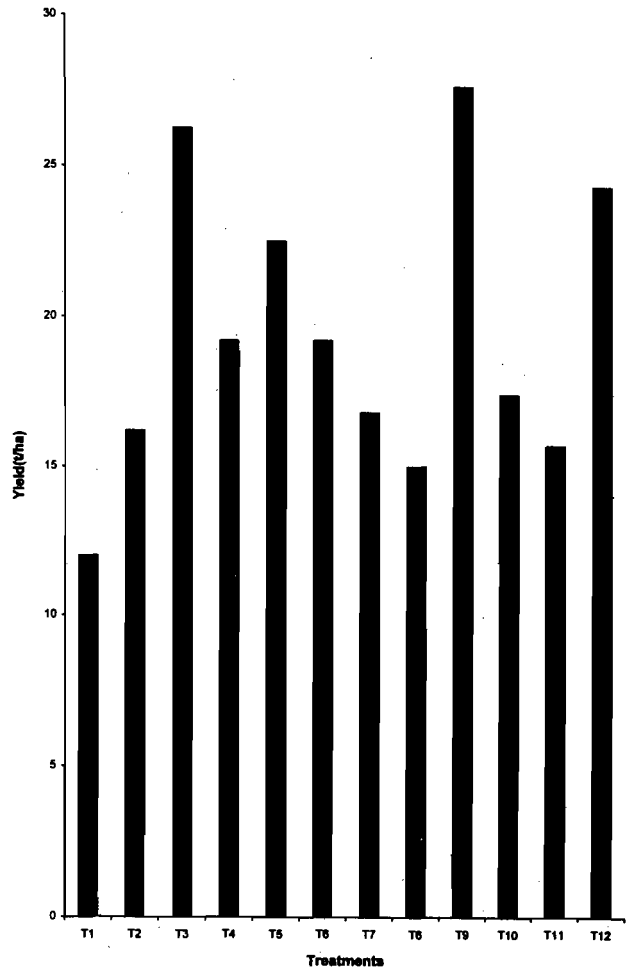
(A.K. Patra and M.R. Pahwa)

Fodder yield

Excessive rainfall events caused heavy losses of applied N (as reflected in the lysimeter studies) resulting into poor responses of fodder yield of maize (cv African tall). Out of the treatments enriched leaf compost was found to be most potential in increasing green fodder yield (27.6 t/ha) (Fig. 10) followed by urea (26.2 t/ha) and vermicompost (24.3 t/ha). Higher effect on green fodder yield with enriched leaf compost may be attributed to the microbial cultures (*Azotobacter* and *Aspergillus awamoori*) added while preparing this compost.

Soil properties

At the termination stage, experimental soil was analyzed for its available nutrients and microbial properties. The data revealed in general more organic carbon content and available N, Na, K and P under different organic resources amended soil. Thus, the study revealed greater availability of nutrients in soil on application of preferably microbial inoculants rich leaf compost. Higher



T1 (control, NPK 0:0:0), T2 (Control, NPK 0:60:60), T3 (urea 100 kg N/ha), T4 (leucaena leaves 50% N + urea 50% N), T5 (Parthenium 50% N + urea 50% N), T6 (neem 50% N + urea 50% N), T7 (Sesbania as green manure intercropped with maize + urea 50% N), T8 (green gram intercropped with maize + urea 50% N), T9 (enriched leaf compost + urea 50% N), T10 (leaf compost + 50% N), T11 (FYM 50% N + uera 50% N), T12 (vermicompost + urea 50% N).

P_2O_5 and K_2O @ 60 kg/ha were applied in treatments T2 and T12. In T7 and T8, sesbania and green gram were incorporated after 2 months. Green gram pods were harvested before incorporation.

Fig. 10 : Effect of organic resources on the green fodder yield of maize (cv African tall)

population counts of fungi, (20 x 10^5 c.f.u/ g soil) was observed in enriched leaf compost amended soil, followed by leaf compost and then in case of parthenium treated soil.

Gaseous losses of N

From the 90 days observations it has been found that black soil is more favourable in showing higher NH_3 losses than red soil. Of the different treatments as high as 15.4% of the applied N was lost when black soil was amended with urea alone and the soil moisture was maintained at field capacity. From red soil this loss was 9.8%. Such losses were maximum in the first month after application of N and reduced to a great extent when leafy materials were used at various proportions. Leafy materials, such as, *Neem* and parthenium were found to be most potential in reducing such losses when they were applied along with urea.

Microbial decomposition of leaf litter

The highest rate of CO_2 evolution on the 5th day, which ranged from 31.3 to 42.2 mg/100 g in black soil and 23.3 to 64.1 mg in the case of red soil, respectively. *Leucaena* application in red soil recorded the maximum evolution (64.1 mg). The cumulative amount of Co_2 evolved with different leafy materials at the end of 50 days showed *Neem* (250.4 mg) ; *Leucaena* (246.3 mg); *Parthenium* (243.3 mg); *Sesbania* (214.1 mg); 50 ppm inorganic-N 188.2 mg) and control (164.7 mg) in black soil, while in red soil the values were 236.7 mg, 255.6 mg, 262.5 mg, 181.8 mg and 168.4 mg, respectively.

With respect to microbial properties, a marked increase in bacterial population was noticed with all the leafy material treatments on the 10th day, the increase being more pronounced with *Leucaena* in both soils (red soil - 12.5 x 10^6 c.f.u/g; black soil - 3.15 x 10^6 c.f.u/g; black soil - 14.1 x 10^6 c.f.u/g soil). As regards actinomycetes, the population increased markedly on the 15th day and again on the 30th day. *Leucaena* supported the maximum population (32.3 x 10^6 c.f.u/g soil) in red soil. Fungal activity was very meager during the 10th and 30th days, later on at termination stage, recorded an increase was recorded in case of *Sesbania* and *Parthenium* amended soils (*Sesbania* - 2.4-9.5 x 10^4 c.f.u/g soil; Parthenium 1.7-10.0 x 10^4 c.f.u/g soil). The addition of inorganic-N with leafy materials indicated decreased *Azatobactor* population in both the soils.

1.5 Evapotranspiration studies in forage crops through lysimetery

(Pradeep Behari and J.B. Singh)

During 171 days of crop growth period of berseem cv. Wardan, 802.1 mm cumulative evapotranspiration was recorded as 5.0 mm/day in and around lysimeter. Cumulative green forage yield of 69.23 t/ ha was obtained from lysimeter in five cuttings at an interval of 50, 32, 30, 28 and 31 days. On the basis of different cuttings, the mean water use efficiency was 14.1 kg DM/ha mm for lysimeter. In

second cutting comparatively poor green forage yield was recorded because of heavy infestation of root rot disease. To control the disease a foliar application of Bavistin @ 0.1% was done. Higher green forage yield obtained at fourth cutting (18.34 t/ha) at 28 days of cutting interval followed by third cutting (17.16 t/ha) at 30 days cutting interval (Table 14).

Table 14 : Forage yield, water use efficiency and ET of berseem at different cuttings

Cutting stage	GM Yield (t/ha)		GM Yield (t/ha)		Periodical ET (mm)	ET (mm)	W.U.E. kg DM/ ha mm (on Ly-simeter
	Lys.	Field	Lys.	Field			
Ist	13.61	13.17	1.45	1.10	123.7	2.47	11.7
IInd	8.88	8.83	1.02	1.01	91.8	2.87	11.1
IIIrd	17.16	15.50	2.31	2.14	143.4	4.78	16.1
IVth	18.34	18.28	3.26	3.29	173.5	6.20	18.8
Vth	11.24	9.00	3.43	3.49	269.7	8.70	12.7
Total	69.23	64.78	11.47	11.03	802.1	-	-
Mean	-	-	-	-	-	5.00	14.1

In *kharif*, maize + cowpea in paired row spacing was sown in and around lysimeters. During 71 days of crop growth period, the average evapotranspiration for 64 days was 5.5 mm/day which gave 390.5 mm total evapotranspiration for combined crop growth period. The green forage yield of maize and cowpea was 14.20 and 13.61 t/ha on lysimeter and 4.34 and 4.12 t/ha at field, respectively. The water use efficiency for mixed cropping was 14.06 kg DM/ha mm (Table 15).

Table 15 : Forage yield, water use efficiency and ET of maize and cowpea

Crop	GM yield (t/ha)		DM yield (t/ha)		Total ET mm	Water use efficiency kg DM/ha (on lysimeter)
	on lys.	in field	on lys. mm	in field		
Maize	14.20	4.34	2.97	0.95	-	-
Cowpea	13.61	4.12	2.52	0.85	-	-
Total	27.81	8.46	5.49	1.80	390.5	14.06

During *rabi*, the PET values between successive cutting intervals i.e. I-II, II-III, III-IV were found to be 73, 90 and 140 mm, respectively. Further, during 1994-95 the PET value for I-II, II-III, III-IV, IV-V cuttings are 47, 71, 102 and 149 mm, respectively. For *kharif* 1993, the PET values for knee high, tusseling and silking stage were 174, 65 and 67 mm, respectively. During *kharif*, the total PET from sowing to harvesting was 268 mm. During *kharif*, the PET value amounted to 128 mm (knee high stage) 64 mm (Tusseling stage) and 94 mm (silking stage).

2.1 Studies on bacterial mediated N_2 fixation for increased productivity in forage crops including pasture and shrub cum tree legumes

2.1.1 Studies on biological nitrogen fixation in grass legume mixed pasture system.

(M.R. Pahwa and A.K. Patra)

Selection of efficient Rhizobium for *Stylosanthes hamata*

Surface sterilized seeds of *S.hamata* and *Cenchrus ciliaris* were sown in pots containing red and medium black soil.

Ten efficient strains of *Rhizobium* (native strains-JSB-4, JSB-6, JSB-7, JSR-3, JSR-4 and JSR-6); exotic (TAI-309 of USA, ISI-2 and ISI-5 of UK and CB-82 of Australia) were tested for their relative efficacy. The results (Table 16) revealed that JSR-3, JSB-4, JSR-4, JSB-6 and CB-82 were highly efficient. The use of antibiotic labeled strains, JSR-3 (strept) and JSR-4 (Strept) studies demonstrated their 100% occupancy in nodules. The results suggest greater suitability and competitiveness of local strains over imported ones on *S. hamata*.

Between the two strains of JSB-4 and JSR-4 originally isolated from medium black and red soils, respectively when tried under medium black soil, the efficacy of JSB-4 was noticed to be greater as compared to JSR-4 (JSB-4-DM yield/pot 9.69 g; JSR-4-9.10 g). This was also confirmed by using antibiotic labeled strains along with them. These results suggest proper selection of efficient strains with respect to soil type for better yield benefits.

Out of five different strains (JSR-3, JSR-4, JSB-4, JSB & 6 TAL-309) tested for their efficacy with respect to soil fertility gradients (control-no nutrients, N.P.K. - 10 + 30 + 20 kg/ha, N.P.K. - 15 + 45 + 30 kg/ha, and 20 + 60 + 40 kg/ha, respectively). Inoculation with strain JSB-4 existed relatively higher efficiency at all the four tried levels of fertility, followed by JSB-6. Thus, the results suggested that the strains producing comparatively greater benefits under varied range of fertility should be selected for inoculation.

Investigations to assess the contribution of different strains of Stylo Rhizobium (JSR-4, JSB-4, JSR-4 (Strept), ISI-2 and TAL-309) under mixed pasture (*S.hamata*) and (*C.ciliaris*) condition indicated higher total green forage yield (28.5 g/pot) on inoculation with JSR-4, followed by TAL-

Table 16 : Relative efficacy and index of effectiveness of Stylo *Rhizobium* strains

Treatments	Dry forage yield g/pot	% increase with I	Relative efficacy (R.E.)	Index of effectiveness (Ei)
Uninoculated Control (UI)	9.09	-	-	-
UI + N	11.00	-	-	-
JSB-4 (Jhansi Stylo Black Soil)	12.51	37.6	116	HE
JSB-6	12.14	33.5	113	HE
JSB-7	10.60	16.6	98	E
JSR-3 (Jhansi Stylo Red soil)	13.12	44.3	122	HE
JSR-4	12.31	35.4	114	HE
JSR-6	10.80	18.8	100	H
CB-82 (Australia)	11.26	23.9	105	HE
ISI-2 (IGER(UK) Stylo)	10.24	12.6	95	E
ISI-5	10.35	13.8	96	E
TAL-309 (USA)	10.74	18.1	100	E

309 (28.0 g/pot). Antibiotic labeled strain JSR-4 also showed 100% occupancy of rhizobia in nodules, confirming thereby, the competence of this strain in legume based mixed pasture condition. Higher N content (1.25%) in the grass was also noticed when grown in association with stylo inoculated with strain JSR-4.

Studies on survival of Rhizobia

The aim of this study was to evaluate the effect of soil temperature, moisture and their interaction on the survival of strains. The results of the laboratory incubation study indicated varied response of two strains (JSR-4 and TAL-309) with respect

to high temperature and soil moisture conditions (Optimum water holding capacity and 50% water holding capacity). Both the strains still showed higher population of rhizobia (10-35 x 10^6 cells/ g soil) under half the optimum water holding capacity and soil temperature regime of 37°C.

4.1 Amelioration and management of salt affected soils

(R.B. Yadava)

Under the collaborative programme of the Institute on salt affected soils with Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, an experiment was started in July 1994 at Daleepnagar Farm of the University. Five grasses *viz.*, Rhodes grass, para grass, setaria, thin napier and Trispecific hybrid were planted in association with four tree species (*Sheesham*, *Subabool*, *Siris* and *Neem*) without application of any amendment under sodic conditions (pH 8.5-10.4, EC 0.27-1.63 d S/m and ESP 18-88).

The analysis of surface soil samples collected after about one year of experimentation indicated no considerable change in the soil pH and ESP under any of the grass species. Also, slight reduction noticed in electrical conductivity values did not show any specific trend with respect to grass species.

DIVISION OF PLANT ANIMAL RELATIONSHIP

1.1 Effect of supplementation of urea-molasses-mineral-block (UMMB) licks to low grade roughage ration on milk production and reproduction in low yielding cattle

(B. Srinivas and N.C. Verma)

Propagation of UMMB supplementation for milch animals at villages

Urea-molasses-mineral-block licks distribution for livestock owners has been continued for second year. Feeding was monitored twice in a week. Average lick consumption was between 250-350 g/day. Out of selected beneficiaries 43% withdrew due to disinclination of animals towards lick consumption. Data was collected by personal interview. Most of the beneficiaries approved ease in handling, increase in roughage intake, reduction in concentrate requirement, improvement in health and milk yield. However, beneficiaries disagree for complete replacement of concentrate mixture with UMMB lick for milch animals and, on improvement in fat/khoa content of milk. Repeatability of opinions expressed in previous year and present year was 0.86 ($P< 0.01$), therefore, opinions were stable and dependable. Lower Q-values (0.42 to 1.03) indicated an ambiguity among the statements. Wald-wolfowitx runs test indicated different distribution between independent variables (age, education, family size, land holding, herd size and income) and dependent variable (attitude of beneficiaries). The average attitude score per beneficiary was 39.12%. Categorization of adoption of UMMB lick feeding ranging from excellent to poor showed 'Good' response from livestock owners towards the technology.

1.1.2 On farm observations of reproductive performance of cattle on UMMB supplementation

Long term feeding trials conducted on 20 animals in two equal groups showed that age at first calving for control and experimental animals was 40.8 and 36.5 m, respectively. Inter-calving period for control and experimental animals was 16.9 and 16.3 m, respectively and was not significant. Involution period and inter-service period for control (4.9 and 15.3 m) and UMMB supplemented groups (4.1 and 14.2 m) also did not vary significantly. However, number of services required for animals were 2.0 in control group and 1.4 for experimental animals and indicated improved conception rate due to additional availability of minerals from UMMB supplement along with non-protein nitrogen and soluble carbohydrates.

1.2 Amelioration of rumen fermentation for efficient utilization of low grade roughage

(R.S. Upadhyaya, L.K. Karnani, B. Srinivas, A.B. Mojumdar and T.A. Khan)

Twelve rumen fistulated adult animals were divided into three groups (GP). GP

1 was fed maintenance ration comprising of *ad. lib.* wheat *bhusa* + 4-6 kg green berseem + concentrate containing 40% maize/barley, 21% wheat bran, 24.5% mustard cake, 10.5% cotton seed cake, 2% common salt and 2% mineral mixture. GP 2 and 3 were also fed the same ration as GP 1 except concentrate which contained 17.5% mustard cake + 17.5% cotton seed cake and 10.5% mustard cake + 24.5% cotton seed cake, respectively.

A digestibility trial was conducted followed by rumen evacuation at 3, 5, 8, 12, 15 and 24 h post feeding. An interval of 24 h was allowed between two evacuations. The solid pool showed irregular trend up to 12 h and gradually declined thereafter. But liquid pool, was reached a maximum of 70.07 ± 0.07, 65.71 ± 0.06 and 56.45 ± 0.06 kg in GP 1, 2 and 3, respectively at 12 h and then declined up to 24 h post feeding.

There was increase in serum protein, albumin and globulin in the blood samples on increasing cotton seed cake proportion in the concentrate (7.71, 7.92 and 8.19 g/dl; 3.05, 3.29 and 3.19 g/dl and 4.66, 4.63 and 5.00 g/dl in groups 1, 2 and 3, respectively). Which may be due to variation in undegradable dietary protein in the cakes.

Total nitrogen (mg/100 ml SRL) and ammonia nitrogen (mg/100 ml SRL) of rumen liquor collected at post feeding showed that there was an increase in the concentration to a level of 84.0, 59.5 and 77.0 mg total nitrogen and 17.62, 16.73 and 24.48 mg ammonia nitrogen in group 1, 2 and 3, respectively at 2 h and then decreased at 6 h with exception to GP 4.

No definite pattern in individual volatile fatty acids ratios was observed. However, there was increase in acetic acids and decrease in propionic acid in GP 3 where green berseem was fed 25% above maintenance.

1.3 Improvement of the nutrient utilization of tropical grasses through strategic supplementation

(K.K. Singh and A.K. Samanta)

1.3.1 Effect of RDN supplementation through range legumes on the *in vitro* organic matter digestibility of *Cenchrus ciliaris*

In vitro OMD was measured exclusively on *C. ciliaris* (C) or in combination with *Lablab purpureus* and *Atylosia scarabaeoides* at three levels of RDN 20, 25 and 30 g/kg DOM. The different combinations of *C. ciliaris* and *L. purpureus* in treatment groups were 74 : 26 in (T_1), 67:33 in (T_2) and in (T_3) small amount of groundnut cake (GNC) was also included in the ratio of 64:26:10. Similarly different ratios of RDN supplemented through *A.scarabaeoides* were 64:36 (T_4), 55:45 (T_5) besides addition of small amount of GNC 64:36:10 (T_6). About 9-19% improvement ($P< 0.05$) in the IVOMD was observed in T_1, T_2 and T_3 over control. Similar improvement was also observed in T_4, T_5 and T_6. There was no significant difference between *L. purpureus* and *A. scarabaeoides* but, *L. purpureus* seems to be a better source of RDN as compared to *A. scarabaeoides*.

Out of three levels of RDN, 25g/kg DOM was strategic level for improving IVOMD.

1.3.2 Effect of various RDN, sulphur and phosphorus ratio on the utilization of *C.ciliaris*

Subsequent to identification of strategic level of RDN as 25 g/kg DOM, strategic level of sulphur (S) and phosphorus (P) were studied. In negative control (Cn) only dry grass was added while in positive control (Cp) *L. purpureus* was added as RDN source. In treatment at groups, 3 levels of S (as sodium sulphate) such as 1.25, (T_1), 1.65 (T_2) and 2.50 (T_3) g/kg DOM was added besides RDN source. Again for each level of S supplement 3 levels of P (as sodium phosphate) such as 3.0, 4.0 and 5.0 g/kg DOM (T_4 to T_6) was added. S and P supplementation had no effect on IVOMD of *C. ciliaris*. The IVOMD ranges between 54.86 to 57.02% for S and between 56.89 to 57.11% for P supplemented treatments and did not differ significantly. It was concluded that the strategic level of RDN, S and P was 25, 1.25 and 3.0 g/kg DOM, respectively for optimum utilization of range grasses.

1.4 Influence of fibre fractions of range grasses and legumes on the availability of macro minerals to ruminant animals

(K.K. Singh, B. Srinivas and A.K. Samanta)

1.4.1 Solubility of macro minerals present in range grasses and legumes in different solvents

Three range grasses (*C. ciliaris*, *H. contortus* and *S. nervosum*) and three range legumes (*S. hamata*, *A. scarabaeoides* and *L. purpureus*) were treated with five solvents viz. distilled water (DW), trio buffer (TB), strained rumen liquor (SRL), neutral detergent solution (NDS) and acid detergent solution (ADS) to assess the solubility of macro minerals. Solubility of minerals was better in ADS followed by NDS, TB, DW, SRL. The range of solubility of macro minerals among solvents was Ca 10-94%, Mg 70-99%, P 63-100%, S 51-100%, Na 85-100% and K 87-100%.

1.4.2 Degradability of cell walls and release of macro minerals in the rumen environment of low NDF ration

Degradability of cell walls and consequent release of macro mineral from 5 range grasses (*Cenchrus ciliaris*, *H. contortus*, *Chrysopogon fulvus*, *S. nervosum* and *D. annulatum*) and 3 range legumes (*S. hamata*, *A. scarabaeoides* and *L. purpureus*) under a rumen environment of low NDF diet, consisting of grass hay *ad. lib*, *S. hamata* 2 kg and concentrate mixture 1 kg, was studied.

Rumen pH was between 6.97 to 7.26 and indicated strong buffering capacity of ration. The total volume of rumen contents was 72 kg with a dry matter content of 14%. The rate of intake (K_1) was 60.11%, rate of passage K_p) was 32.11%, rate of digestion (Ka) was 36.41% and rate of true digestion (Kat) was 58.54%. Maximum concentration of different nitrogen components such as total-N, ammonia-N, TCA-N and NPN

were maximum at 16 h of post feeding while TVFA concentration was at peak at 12 h of post feeding only. The mean ammonia-N concentration was 121 mg/1. The proportion of TCA-N and NPN in the total-N was 58.35 and 41.65%, respectively. The mean TVFA concentration was 56.51 ± 6.36 meq/1.

In Sacco dry matter disappearance was 18-65% in range grasses and 25-70% in range legumes between zero to 96 h of incubation. The NDF disappearance in range grasses (53%) was higher than legumes (43%). The extent of disappearance was maximized by 3 h for K and Na, by 12 h for S, P and Mg and by 48 h for Ca. Release of macro minerals was higher for range legume than range grasses.

1.5 Studies on the relationship between intake and physico chemical characteristics of new forage

(V.C. Pachauri)

Three varieties of Dolichos viz. 13-1, JLP-3 and JLP-4 were harvested at flowering stage, dried and conserved as hay. Samples were analyzed for proximate estimates, NDF and ADF (Table 17a).

Table 17 (a) : Chemical composition (DM basis) of three varieties of Dolichos

Variety	CP	CF	EE	NFE	NDF	ADF	Ash
13-1	13.85	27.19	1.56	48.87	55.67	37.64	8.53
JLP-3	15.65	29.00	1.74	44.69	51.20	37.60	8.92
JLP-4	12.57	32.59	1.34	44.76	50.24	40.67	8.74

Table 17 (b) : Dry matter intake and nutrients of three varieties of Dolichos

Variety	DM (kg)	DM (%) L. wt.	DM g $W^{0.75}$	DCP (g)	DCP g $W^{0.75}$	TDN (g)	TDN g $W^{0.75}$
13-1	1.18	4.45	100.68	120.77	10.26	775.00	66.35
JLP-3	1.20	4.80	108.64	128.02	11.36	786.30	69.61
JLP-4	1.00	4.00	88.89	89.49	7.99	680.30	60.55

Perusal of table 17(a) reveals that CP% in JLP-3 was higher than JLP-4 but contrary was true in CF% among two varieties.

There was no much difference in the digestibility coefficients except NDF which was higher in the variety 13-1.

Dry matter intake and nutritive quality among 3 varieties was higher in JLP-3 than other two varieties and they were lowest in JLP-4. Intake of DCP was significantly higher in JLP-3 (Table 17b).

Voluntary dry matter intake and digestibility values were correlated with

physical parameters *viz.*, packed volume, water retention capacity and solubility in water were also estimated.

No significant correlation was found with water retention capacity and packed volume, DCP intake, ADF% and DM%, NFE% and DM%, ADF%, water retention and DM%, ADF%, water solubility and EE%, NDF%.

1.6 Use of *in vitro* gas production technique for the evaluation of forages

(M.M. Das, L.K. Karnani and V.S. Upadhyay)

The volume of gas produced was measured *in vitro* for 11 varieties of cowpea, 9 varieties of sorghum, 6 varieties of berseem, 4 varieties of oats, 4 species of grasses, 3 species of range legumes. Maximum gas production among the cowpea varieties was observed at 48 h. The volume of gas produced between 24 to 48 h was 40-50% subsequently acceleration in gas production was 10-15% up to 72 h and it was reduced drastically thereafter. After 96 h of incubation maximum cumulative gas production was observed in cowpea CL 341 (54.75 ml) and UPC 93-4 (54,30 ml) and indicated rapid fermentation in these species compared to IFC 9402 (34.45 ml), UPC 93-2 (36.55 ml) and UPC 94-1 (37.05 ml). Among the sorghum varieties, maximum cumulative gas production after 96 h observed in ATS-6 (58.9 ml) and ATS-10 (57.6 ml). The rate of gas production from 24 to 48 hr and 48 to 72 h was almost similar. Among the different varieties of berseem, JHB 93-4 (60.4 ml) and JHB 9403 (56.0 ml) were found to be superior. Similarly in oats UPD 8-4 was found better (60.95 ml) than ASXAST 11-2 (50.75 ml), ASXAST (47.45 ml) and ASXAST (41.05 ml).

Maximum cumulative gas production in range legumes and tree leaves was observed in *L. purpureus* (50.80 ml) and *S. sesban* (52.50 ml) whereas *A. scarbaeoides* and *A. nilotica* produced (44.90 ml) and 34.20 ml. In grasses, excluding *C. ciliaris* (26.10 ml), the gas production was similar in *C. fulvus* (47.80 ml), *S. nervosum* (44.60 ml) and *H. contortus* (45.90 ml). The rate of gas production was faster in range legume than leguminous tree leaves and then grasses. At 48 h, the cumulative gas production was 22.88% and 15.38% higher in range legumes than grasses and tree leaves.

1.7 Phenolic acid components of cell walls of different forages and their effect on digestibility

(N.A. Shakil, A.S. Negi and L.K. Karnani)

Range grasses (*C. ciliaris*, *H. contortus*, *C. fulvus*, *S. nervosum* and *D. annulatum*), range legumes (*S. hamata*, *A. scarabaeoides*, *L. purpureus* and *M. atropurpureum*) and tree leaves (*S. sesban*, *L. leucocephala*, *A. lebbeck* and *A. nilotica*) were analyzed for the presence of phenolic acids viz., Ferulic acid (FA), p-Coumaric acid (PCA) and o-Coumaric acid (OCA) in their cell walls. Amongst three acids, FA

was found to be more widely distributed than PCA and OCA. Concentration of these acids increased with maturity. Among the range grasses, *C. ciliaris* and *D. annulatum* were found to contain the maximum FA content 0.9968-2.52 and 0.988-2.0 mg/g of cell wall, respectively. In range legumes, FA as well as PCA content was maximum in *A. scarabaeoides* (1.967-2.2576 and 0.4587-0.7 mg/g of cell wall, respectively) while in tree leaves, the FA and PCA content was maximum in *A. lebbeck* (1.86-2.5 and 0.5-1.0 mg/g of cell wall, respectively). A little amount of OCA released from the above forage crops. The *in vitro* digestibility of these grasses before and after treatment with 1N NaOH showed an improvement of 30.8% in *C. fulvus* to 155.8% in *H. contortus* in grasses which was marginal in case of leguminous forages. This shows that the cell walls of graminaceous and leguminous forages behave differently on alkali treatment.

2.1.2 On farm trial on silage making/ improvement of low grade roughages

(A.P. Singh, A.K. Misra, P.N. Dwivedi and N.C. Verma)

Silage in *Kachcha* pit was prepared from green maize stover and mature green themeda grass in alternate layers in Bamouri village and with chopped green sorghum stover in village Daily (Jhansi district). It was opened after 2½ months storage. The silage in the peripheral layer of 30 cm depth was poor quality and beneath to it a better palatable good quality silage was obtained. No wastage was found in sorghum stover silage.

2.2 Response of animals fed on ammoniated low grade roughages

(A.B. Mojumdar, A.P. Singh, A.K. Misra and S. Radotra)

2.2.1 Effect of feeding ammoniated mature grass/wheat straw on animal performance

Mature dry grass and wheat straw were treated separately with 4% urea and 50% water. Growth study was undertaken on crossbred heifer randomly distributed into 3 treatments. Animals of treatment group T_1 were fed on Untreated mature dry grass + concentrate mixture @ 1% body weight, while in T_2 Ammoniated grass/straw + concentrate mixture @ 0.75% body weight was offered. In 3rd treatment group T_3 the diet was same that of T_2 and in addition 0.1% S was added in concentrate mixture.

Dry matter intake (kg) was found higher in T_2 (3.31) than T_1 (3.26 and T_3 (3.20). Similarly, growth rate (g/d) was also higher in T_2 than other two groups. Ammoniation was able to increase dry matter digestibility by about 8%. Addition of S had no impact on animal performance and nutrient utilization. Blood urea N (mg/100 ml), blood urea (mg%), NH_3-N (mg/100 ml) were higher in T_2 and T_3 than in T_1, but below the toxic limits. Serum protein, albumin and globulin were unaffected on feeding of ammoniated grass. Similar study was further conducted on ammoniated wheat straw.

Ammoniated wheat straw

DMI in T_1, T_2 and T_3 were 3.83, 3.46 and 3.19 kg respectively. Higher dry matter digestibility were observed in ammoniated wheat straw fed groups . Blood profile showed a trend similar on feeding of ammoniated dry grass. It can be concluded that ammoniation reduced concentrate requirement by 25% for growing calves and increased the DM digestibility without advertently effecting blood metabolics.

2.2.2 Effect of feeding ammoniated dry grass with and without addition of sulphur on milch cattle

Ammoniated dry grass (4% urea and 50% water) was fed to 2 equal groups of 6 milch cattle along with 4 kg green sorghum and concentrate as per requirement and served as control or in treatment group 0.1% was added in addition to control diet.

Sulphur supplementation had no added advantage on DMI, milk yield and its composition and blood metabolities.

2.3 Utilization of shrubs and tree leaves as animal feed

(V.S. Upadhyay, B.K. Bhadoria and P.N. Dwivedi)

Four species of Zizyphus i.e. *Z. nummularia*, *Z. zylopyrus*, *Z. oenoploea* and *Z. jujuba* were evaluated for quality and antiquality parameters.

In sacco dry matter degradability indicated that DM degradation at 72 hours was maximum in *Z. oenoploea* (54.25%), followed by *Z. nummularia* (53.65%), *Z. zylopyrus* (53.50%) and *Z. jujuba* (43.60%). Cumulative gas production at 96 hours was significantly higher in *Z. oenoploea* (51.65%) than *Z. jujuba* (46.95 ml) whereas it was similar in *Z. zylopyrus* (50.95 ml) and *Z. nummularia* (50.80 ml). The rate of gas production (cg) was also higher in *Z. oenoploea*. The level of VFA (m Eq/100 ml SRL) after *in vitro* incubation of 24 and 48 h were almost similar in different species. The voluntary intake DM was similar in three species but DM was significantly lower in *Z. jujuba* than *Z. zylopyrus* and than *Z. nummularia* . Similarly CP, CF, NDF, ADF and hemicellulose digestibility were also significantly higher in *Z. nummularia* and *Z. zylopyrus* than *Z. jujuba*.

3.1.1 Studies on feed resources availability and traditional livestock rearing practices followed in Bundelkhand region of U.P.

(A.K. Mishra and P.N. Dwivedi)

Two districts of Bundelkhand region of U.P. i.e. Jhansi and Lalitpur were selected. Further, two blocks from each district (Babina and Badagaon from Jhansi and Talbehat and Jakhora from Lalitpur) were covered and in each block, two villages were selected for survey.

Feed resources

Crop residues, grasses are the major feed resources, Trees and shrubs were alternative source of green fodder during lean period.

Feeding and management practices

Animals were mostly maintained under free grazing system with little inputs. Concentrate ingredients for lactating buffaloes were mainly cotton seed cake and gram chunni and fed as *sani*. On an average a buffalo yielding 8 litres of milk was fed 4 kg home made concentrate, 10-15 kg green fodder and 4-5 kg dry fodder. There was no attention for mineral mixture and common salt supplementation by the farmers. The average milk yield of cows and buffaloes was higher in Jhansi district as compared to Lalitpur district (cows 2.26 vs 1.93, buffaloes 4.52 vs 3.52 l/d). However, the productivity of goats was better in Lalitpur as compared to Jhansi district due to availability of more forest grazing lands in Lalitpur district. The average age at first calving, calving interval and dry period for desi cows are 49.2, 20.2 and 14.5 months respectively. The seasonal calving pattern of cows and buffaloes indicated ' that more number of cows calved in summer (45.1%) and buffaloes calved in winter (48.08%).

DIVISION OF SEED TECHNOLOGY

1.1 Studies on crop geometry, fertilizer use and moisture stress in relation to seed production in forage crops

(P.S.Tomer, S.N.Singh and A.A.Khan)

Seed production efficiency of promising varieties of cowpea in relation to dates of sowing

A field experiment comprising 4 varieties of cowpea (IFC-9304, IFC-901, IGFRI-450 and NP-3) and 3 dates of sowing (10 July, 30 July and 19 August) was conducted in randomized block design.

Early sown cowpea on 10th July excelled late sown in seed production since maximum seed production (6.75 q/ha) was obtained from 10th July sown crop followed by 30 July (5.00 q/ha) and 19th August (1.35 q/ha) sown crop. Further, it was noted that NP-3 (5.40 q/ha) closely followed by IGFRI 450 (4.55 q/ha) produced significantly higher seed yield over IFC-9304 and IFC 901.

A study on quality seed production of lucerne under variable seed rates and cutting management

An experiment comprising 4 seed rates (3 to 12 kg/ha) and 4 cutting management (uncut, one cut, two cut and three cut) was conducted in strip plot design.

Lucerne seed and forage production as well as gross income remained unaltered due to different seed rates tried (3 to 12 kg/ha seed rates). However, seed yield decreased remarkably (67.37 kg with no cut and 16.50 kg with three cuts). Forage yield as well as gross income decreased with less number of cuttings.

1.2 Agronomical investigation in pasture legume seed production

(G.K.Dwivedi and P.S.Tomer)

Effect of cutting management and KNO_3 foliar feeding on seed production of *Stylosanthes hamata* grown with and without irrigation

The field experiment continued during the 3rd year to assess the effect of cutting management (uncut and one cutting) and KNO_3 application on seed yield of *Stylosanthes hamata* grown with one irrigation and without irrigation.

Uncut crop produced significantly higher seed yield (244 kg/ha) as compared to crop cut once (205 kg/ha). Irrigated and unirrigated crop does not show any significant change in seed yield.

Foliar spray of KNO_3 @ 6 kg/ha increased the seed yield to 271 kg/ha against 172 kg/ha with control treatment. Use of KNO_3 beyond 4 kg/ha did not prove beneficial.

1.4 Agronomic investigation for increasing seed yield in grasses

(G.K.Dwivedi)

Studies on nitrogen economy by pasture legumes association for higher seed production in *Setaria sphacelata*

A field experiment was continued in third year to assess the nitrogen economy on seed production of *Setaria sphacelata* through introduction of pasture legumes, *viz.*, *Sesbania sesban, Desmanthus virgatus, Stylosanthes scabra, Clitoria ternatea* and *Desmodium tortosum* at different levels of nitrogen (0, 20, 40, 60 and 80 kg N/ha).

Increasing doses of nitrogen (up to 60 kg N/ha) gradually increased the seed yield of grass (53.8 kg/ha). Among legumes, the association of *Clitoria ternatea* produced the highest seed yield of grass (50.1 kg/ha) followed by the association of *Stylosanthes scabra* (49.9 kg/ha). These levels of seed production were equivalent to 40 kg fertilizer N/ha (48.8 kg/ha). Sole grass produced the minimum seed yield (36.4 kg/ha).

Besides, enhancing seed yield of grass and effects on economy in fertilizer N, the dry forage yield of pasture legumes were in the order of *Sesbania sesban* (4.59 t/ha) > *Stylosanthes scabra* (4.40 t/ha)> *Desmanthus virgatus* (4.29 t/ha) > *Clitoria ternatea* (2.72 t/ha) > *Desmodium tortosum* (0.85 t/ha).

Studies on nitrogen application and cutting management for higher seed production in *Setaria sphacelata*

A field experiment was conducted with four levels of nitrogen (0, 40, 80 and 120 kg N/ha) and three treatment of cutting management (Lopping, cut once and uncut) in a randomized block design.

During the establishment year, maximum seed yield (62.2 kg/ha and 59.9 kg/ha) was at par with the application of 120 kg N/ha and 80 kg N/ha respectively. Minimum seed yield (49.3 kg/ha) was obtained in the control (no nitrogen). As regards to cutting management treatment, the maximum seed yield (62.4 kg/ha) was obtained with the uncut crop followed by lopping (55.0 kg/ha) and cut once (51.6 kg/ha).

2.1 Seed borne diseases and their control in forage crops

(S.N. Singh)

Studies on control of seed-borne diseases especially *Fusarium* rot, rust and downy mildew in lucerne

Field trial was conducted with three fungicides and their combinations as seed dressing as well as their spray at anthesis (Thiram, Plantvax and Bavistin @ 0.3% and 0.15%) against seedling and foliar diseases with Lucerne CV. IGFRI-244 in RBD with three replications.

Treated seeds with Bavistin @ 3 g/kg gave the protection against soil and seed-borne

diseases as well as it provides better germination with increased rate of emergence 49-62.2% along with better stand even against the adverse growing weather conditions.

During the second year the influence of cutting on total shoots per plant, number of florets per flower and number of seeds per pod were less in untreated plots whereas the number of pods per cluster which is the only yield component in Lucerne is greatly benefited by treatments.

The average percentage of leaf infected due to rust (*Uromyces striatus*) was generally low in all the fungicidal plots worked out to be 2.06 with standard error of 0.08 whereas damage due to rust in terms of percentage of tillers was 0.60 with S.E. of 0.05 in Bavistin @ 0.3% sprayed plots. A significant reduction in infection severity was also observed which ranged from 3.30 - 10.25 per cent as compared to unsprayed control (33.30%). The incidence of downy mildew increased progressively from first to third observation as recorded by average score per plant in control.

Significant increase in seed yield was also recorded from Bavistin sprayed plots with a drastic reduction of seed-borne inoculum showing good quality seeds as expressed by increased 1000 seed test weight, percentage of germination in comparison to unsprayed.

Isolation and identification of different micro-organisms associated with seeds of forage crops

In vitro experiment was conducted after harvesting the seeds of different cultivars of *Stylosanthes* species to assess for seed-borne fungi and their seedling symptom test. Seed-borne fungi which were considered as potential pathogens were tested for seedling symptom test. Four seed samples of *Stylosanthes hamata* and *S. humilis* and *S. guianensis* with 22.0, 38.5 and 58.5% natural infection respectively of *Colletotrichum gloeosporioides* and *Fusarium equiseti* were used for the study. In all the samples tested, pre and post emergence mortality with seedling rot, symptoms of anthracnose and other leaf spots were observed. *Rhizoctoria solani* was more prevalent showing foliar blight in *S. guianensis* cultivars.

3.1 Studies on insect pest pathogens in seed storage

(S.N. Singh and A.A. Khan)

Effect of containers and pesticides on the incidence of storage pest-pathogens and storability of *Dolichos* and maize seeds

An experiment of seed storage of *Dolichos* (CV.JLP-3 and JLP-4) and maize (local) with initial moisture content of 9.9 and 12.2 percent respectively was taken up. The storage containers viz. cloth, gunny bags, tin box, earthen pots, polyethylene bags and plastic bags were used after treating the seed with neem leaf and Nirgundi (1:100), Malathion and Bavistin @ 0.1% (1:1) under ambient conditions. The stored seeds were tested at three monthly intervals for insect and pathogen infestation as well as for their viability during 45 months of storage.

It was observed that the perforated containers lost germinability faster than the seeds stored in sealed plastic jars and polyethylene bags owing to rapid loss of moisture in the former especially during summer period due to high temperature after 18 months of storage.

The treatment with pesticides played a protective role in maintaining the vigour as compared with the control where viability reduced with increased insect infestation appreciably after 24 months of storage.

Bavistin and Bavistin + Malathion (1:1) @ 1 g/kg seed were found to be significantly effective in reducing the storage fungi as well as insect infestation. The occurrence of saprophytes like *Aspergilus restrictus, A. glaucus, A. flavus, Fusarium moniliforme, Penicillium, Rhizopus* and *Mucor* sp. in non treated seeds leads to reduction in seed germination. No linear relationship was observed between seed germination and seedling vigour. It was also observed that conditions favourable for longevity of the seeds are usually favourable for longevity of the pathogen so the inherent longevity of both must be considered.

Effect of botanicals on insect pest pathogens and germinability in *Dolichos* and maize seeds

Dolichos and Maize seeds were stored in polyethylene bags (700 gauge) and plastic jars after treating with the extract of botanicals viz. *Croton tiglium, Acorus calamus, A. indica* and *Vitex negundo* @ 0.5, 1.0 and 1.5 ml/kg seed in order to assess their efficacy against the storage fungi and infestation of insects under ambient condition.

Germination

The main effects of seed moisture and interaction effects viz. treatment x period x moisture were significant on germination. The viability drops to 42-33% percent germination in both seeds with abnormal seedlings in untreated seeds as compared to *Croton* and *Acorus* treated seeds (82-68 per cent) with positive influence in seedling vigour after 42 months of storage. No linear relationship was observed between seed germination and seedling vigour with the passage of time.

Bioefficacy

Effect of treatment with botanical extracts @ 1.0 ml/kg effectively controlled Bruchid and *Trogoderma* development with reproductive inhibition up to 92% during 45 months of storage in both types of seed respectively. Normal egg laying and development of grain borer in *Dolichos* (*Collosobruchus chinensis*) and *Trogoderma* in maize seeds was noticed in untreated seeds where none of the seeds germinated after 15 months of storage.

Seed vigour as measured by the rate of germination and seedling root and shoot length declined before the decline in seed viability beyond 44 months of storage with no significant effect on germination in treated seeds with botanicals in comparison to control where germinability

and vigour reduced drastically with the increase of storage period even after 15 months of storage. Thus it is concluded that among botanicals *Croton tiglium* and *Acorus calamus* which are nontoxic and cheap could be incorporated as a pre-storage seed treatment to improve seed longevity.

DIVISION OF PLANT PHYSIOLOGY AND BIOCHEMISTRY

PPB-1 : PHYSIOLOGICAL STUDIES IN FORAGE CROP IMPROVEMENT

1.1 Varietal screening for drought tolerance in oats

(R. K. Bhatt and L. P. Misra)

Eight promising genotypes of Oat (*viz.*, JHO 810, 822, 861, 884, 886, 888, 889 and IGFRI 3021) were assessed for drought tolerance potential under different irrigation treatments given at different stages of growth. The morphophysiological observations were recorded at 50% flowering stage. The dry matter yield, leaf area index, and seed yield were affected adversely in stress condition (where no irrigation was provided throughout the growth period), JHO 884 produced maximum dry matter yield under stress conditions followed by JHO 822 while it was at par in JHO 886, 889 and 861 thus indicating their high drought tolerance index (Table 18). Higher specific leaf mass in JHO 822 and 884 supported their relative drought tolerance than other genotypes tested (Table 19). JHO 822 also produced higher seed yield further proving superiority over the other genotypes with respect to seed production under stress environment.

Irrigation given at seedling plus jointing stage increased the biomass production as compared to irrigation given at seedling plus tillering stage in all the genotypes except in JHO 822 in which dry matter yield was similar under both the irrigation treatments.

Rate of photosynthesis, stomatal conductance, transpiration, PN/TR (water

Table 18 : Variation in dry matter yield (g/m²) in oat genotypes

Genotypes	T_1	T_2	T_3	T_4	T_5	Average
JHO 810	675.39	886.34	964.56	1115.58	1149.48	958.27
JHO 822	861.84	988.64	1360.40	1350.68	1417.95	1195.90
JHO 861	806.69	1029.80	1086.44	1296.04	1449.39	1133.67
JHO 884	867.69	891.75	1058.17	1251.68	1322.48	1078.35
JHO 886	814.62	854.88	1083.94	1230.67	1391.77	1075.18
JHO 888	727.77	868.16	1018.95	1213.38	1293.10	1024.27
JHO 889	812.25	916.33	1101.79	1133.09	1307.06	1054.10
IGFRI 3021	657.88	921.58	1192.33	1354.24	1462.41	1117.69

T_1 - Stress (No irrigation), T_2 - Irri. at seedling, T_3 - T_2+irri. at tillering, T_4 - T_2+irri. at jointing, T_5 - $T_2+T_3+T_4$+irri. at 50% flowering

Table 19 : Specific leaf weight (SLW), leaf area index (LAI) and seed yield in oat genotypes under stress and non stress conditions

Genotypes	SLW (mg/cm^2)		LAI		Seed yield (g/m^2)	
	Stress	Non-stress	Stress	Non-stress	Stress	Non-stress
JHO 810	4.55	4.10	2.41	7.38	220.14	327.07
JHO 822	5.50	4.81	3.77	6.88	358.41	444.25
JHO 861	4.21	3.83	5.92	9.41	297.27	318.49
JHO 884	4.91	4.76	3.33	6.72	246.11	323.84
JHO 886	4.81	4.78	3.06	6.60	232.51	325.91
JHO 888	4.45	4.39	2.89	5.74	257.91	349.18
JHO 889	4.61	4.46	3.81	5.98	216.45	291.57
IGFRI 3021	4.89	4.86	3.02	8.43	284.96	394.87

Stress = No irrigation and Non-stress = Irrigation at all stages of growth

Table 20 : Physiological characters in oat genotypes as influenced by stress and non stress conditions

Genotypes	PN (μ mol/m^2/s)		CINT (ppm)		CS (cm/s)		TR (μ mol/m^2/s)		PN/TR		PN/CINT	
	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS
JHO 810	7.91	21.39	209	253	0.23	1.30	2.34	5.93	3.38	3.60	0.038	0.084
JHO 822	7.38	16.37	206	231	0.23	0.70	2.68	4.97	2.75	3.29	0.036	0.079
JHO 861	7.08	15.88	212	227	0.22	0.65	2.34	4.99	3.03	3.18	0.033	0.069
JHO 884	7.79	16.35	201	226	0.25	0.72	2.39	4.29	3.26	3.81	0.038	0.072
JHO 886	7.04	19.90	211	217	0.23	0.76	2.36	6.05	2.98	3.29	0.033	0.092
JHO 888	6.60	17.21	217	214	0.21	0.70	2.23	5.25	2.96	3.28	0.030	0.084
JHO 889	7.02	20.23	242	222	0.22	0.83	2.27	5.43	3.09	3.72	0.029	0.091
IGFRI3021	7.71	20.10	222	222	0.24	0.80	2.54	5.54	3.03	3.62	0.034	0.090

S= Stress (no irrigation), NS= Non-stress (irrigation at all stages)

use efficiency) and PN/CINT (carboxylation efficiency) reduced to a great extent in all the genotypes under stress condition (Table 20). The reduction in CO_2 assimilation may be due to higher reduction in stomatal conductance. However, JHO 884 maintained relatively higher stomatal conductance and also accumulated maximum chl b under stress environment indicating its potential to water stress tolerance.

1.6 Interaction of light interception and energy exchange on growth and development of forage under silvipastoral system

(L. P. Misra and R. K. Bhatt)

Physiological process in grasses under Leucaena and Acacia tree canopies

The growth, biomass production and other

physiological phenomenon of *P. maximum* and *C. ciliaris* were evaluated during the first year of establishment when grown beneath 13 years old trees of *Leucaena leucocephala* and *A. tortilis*, respectively. The dry matter yield, Leaf area index and specific leaf mass of these grasses generally decreased under shade of tree canopies but the reduction was observed more in *P.maximum* indicating its poor association under high shading degree of Leucaena canopies. The reduction in these parameters in *C.ciliaris* was minimum under the canopies of *A.tortilis* showing its better adaptation potential (Table 21).

Table 21 : Morphophysiological characters of grasses under silvipastoral system of *L. leucocephala* and *A. tortilis*

Grass speciest	Canopy	DMY (g/m^2)	LAI	SLW (mg/cm^2)	Photosynthetic pigments (mg/fresh wt.) Chl a	Chl b	a+b	a:b
P. maximum	Open	762.80	6.82	4.80	1.17	0.37	1.54	3.16
	L.leucocephala	336.40	4.87	3.52	0.85	0.33	1.18	2.63
C. ciliaris	Open	296.04	3.46	5.91	0.42	0.16	0.58	2.65
	A.tortilis	192.26	2.22	5.18	0.65	0.27	0.92	2.56

The accumulation of chl- a and chl- b was high in *P. maximum* as compared to *C. ciliaris* in open as well as under tree canopies. However, *C. ciliaris* accumulated more chl-b under shade of Acacia trees than to the open condition, thus, exhibiting its shade adaptation potential.

The rate of photosynthesis, transpiration, stomatal conductance, leaf temperature, PN/TR and PN/CINT were decreased in both the grasses under shade trees canopies. In *P.maximum* these physiological characters were reduced (Table 22) to a great extent because of lower availability of photosynthetically active radiation (PAR). PAR showed positive and significant correlation with PN (r = .8359) and CS (r = .7134) indicating the interdependence of these

Table 22 : Effect of *Leuceana* and *Acacia* canopies on physiological charecters of *P. maximum* and *C. ciliaris*

Grass species	canopy	PAR µ mol/ m^2/s	LT C	PN µ mol/ m^2/s	CINT ppm	CS cm/s	TR µ mol/ m^2/s	PN/TR	PN/CINT
P.maximum	Open	1850	36.20	34.91	154	1.19	11.80	2.96	0.223
	L.leucocephala	590	33.15	9.74	176	0.23	4.25	2.29	0.055
C.ciliaris	Open	1868	35.96	36.19	135	1.11	9.23	3.92	0.266
	A.tortilis	946	33.91	13.37	182	0.38	5.12	2.61	0.073

characters. The rate of CO_2 assimilation was intimately associated with stomatal conductance (r = 0.8796). The higher accumulation of chl-b and lower reduction of stomatal conductance and specific leaf mass are the primary indices for shade tolerance. The higher assimilation rate in *C. ciliaris* . under *A. tortilis* is due to higher availability of PAR as compared to *L. leucocephala* canopies. Under tree canopies the optimum and sustained productivity of under growing crops can be achieved by allowing the required amount of PAR during the growth period of crops. This can be achieved either by lopping, pruning and polarding the tree canopies or through maintaining the optimum spacing between the trees.

Micro - environmental changes under *Leucaena - Panicum* based silvipastoral system

The micro - environmental changes under the Leucaena canopies were recorded by an automatic weather data recording system. The photosynthetically active radiation (PAR) and global radiation reduced to minimum level during the full canopy growth (July - December). On an average, the canopies of Leucaena at the spacing of 5 X 5 m allowed only 25 - 30% of total PAR. The relative humidity was higher under tree canopies compared to open condition. The canopy temperature and under canopy temperature of Leucaena trees were lower to air temperature. The increase in relative humidity and decrease in temperature and radiation during day time caused the reduction of evapotranspiration in the system. For optimum and sustainable production, it is very essential to maintain the optimum PAR distribution which is the key factor for influencing the other micro-environmental parameters.

PPB-2 : BIOCHEMICAL STUDY IN FORAGE CROP IMPROVEMENT

2.1 Biochemical response of forages to flooding/waterlogging in *Bracharia species*

(Sewa Ram)

The role of lactic acid was confirmed further in inducing intolerance to flooding in sensitive plants. Accumulation of lactic acid induces cytoplasmic acidification which in turn causes cell damage. Catalase levels increased three fold in *B. decumbense* and decreased in *B. mutica* roots under flooding. Reduction in catalase levels in B.mutica might enhance H_2O_2 levels which take part in lignification of cell walls to check flooding induced leaching of nutrients.

Protein profile study was done to see the change in quality and quantity of proteins. Polyacrylamide gel electrophoresis (PAGE) was used to see protein bands. There was no perceptible change in protein profile of leaves in *B. mutica* under flooding while in roots new proteins with the Rf value of 0.10 & 0.12 appeared. The nature and role of these proteins need to be ascertained.

2.2 Biochemical mechanism of disease resistance in some forage crops (cowpea, berseem and stylo)

(Amaresh Chandra)

To study the biochemical and molecular mechanism of disease resistance and susceptibility, six genotypes of cowpea viz IFC 8401, IFC 8402, IFC 902, IFC 901, IGFRI 450 (Kohinoor) and Bundel-2 (8503) showing different level of resistance on the field trial basis were taken for the investigation. All six genotypes were grown in net house as well as in a growth chamber with 14 h photo period (RH 60%, day temperature 32°C, night temperature 22°C) using 5 inch pots. The 0.02% (3.4 mm), pH 6.5 solution of salicylic acid (SA) was used to study the response of systemic acquired resistance in all genotypes by analyzing the different enzymes involved in it. The solution of salicylic acid was supplied both by spraying as well as in form of irrigation at particular time of observations. The control plants were irrigated or sprayed with plain water accordingly. Total phenols were estimated from all six genotypes in SA treated and untreated plants. The maximum level of total phenols were observed in IFC-902 and Bundel 2-(8503) genotypes. After salicylic acid treatment except IFC 8402 rest have showed reduction in the level of total phenols.

The first enzyme of the phenyl propanoid metabolism i.e. phenylanine ammonia lyase (PAL) activity was measured in all six genotypes. Four genotypes out of six showed increase in PAL activity while two showed decreasing trend after two days of SA treatment. The maximum increase in activity was observed in genotype IFC 901. This distinct behaviour showed by the genotype at the level of PAL activity may be indicating the differential extent of systemic acquired resistance (SAR) inductions.

The endogenous salicylic acid present in plant was also measured. The standard solution of salicylic acid showed the retention time of 4.46 minutes when methanol (25%) and water (75%) were used as the solvent.

The total protein profile study by the SDS and native polyacrylamide gel electrophoresis (PAGE) was standardized using 10% gel. The same standardized protocol will be utilized to monitor the expression of pathogenesis related proteins induced by salicylic acid as well as pathogen.

Lipoxygenase and peroxidase activity were also measured in treated and untreated genotypes. The peroxidase activity was measured by using guaicol as a substrate. Here the peroxidase activity infer its role in physiological (e.g. lignification) function as guaicol has been used as a substrate. The activity was found increased in Bundel 2-(8503), IGFRI-450 and IFC-8402 after SA treatment. The activity of lipoxygenase has been found increased in all genotypes after SA treatment.

The activity of catalase enzyme was measured at different intervals of time to find out the response of this enzyme in SAR. The results indicated that the initial response of this enzyme is important for the SAR induction.

DIVISION OF PLANT PROTECTION

PP-1 : STUDIES ON DISEASES, INSECT PESTS AND NEMATODES AND THEIR MANAGEMENT FOR INCREASED FORAGE PRODUCTION

1.1 Diseases of forages and their management

(R.B. Bhaskar and S.T. Ahmad)

Screening for resistance

Cowpea : Cowpea varieties under initial and final evaluation trials of AICRP on forage crops were screened for resistant to cowpea mosaic and root-rot under natural conditions. Resistance to root-rot was also tested under controlled conditions. Varieties IFC-9304, 9402, UPC 93-1, 93-2, 93-4, 941 and 942 were found resistant to root rot.

Berseem : Diploid and tetraploid lines were screened for resistance to root rot (*Rhizoctonia solani, Fusarium semitactum*) Stem rot (*Sclerotinia trifoliorum*) and foliar diseases. Tetraploid lines showed high degree of susceptiblity in comparison to diploids.

Management of diseases

In a field experiment, out of 9 treatments, hot water seed treatment followed by foliar spray of Bavistin (0.1%) resulted into complete control of the diseases. Next effective treatment was seed treatment with Bavistin (0.2%) followed by foliar spray of Bavistin.

Cowpea root-rot : Soil solarization by black polythene cover significantly reduced the inoculum potential of the soil, which resulted in 80% reduction in root-rot of cowpea.

1.3 Insects associated with leguminous forages and their management

(K.C. Pandey and S.A. Faruqui)

Evaluation of germplasm material at AICRP(FC) trials was undertaken. At Jorhat, cowpea entries UPC-952, UPC-953, IFC-9501 and CL-350 showed least damage by flea beetle and defoliators. At Kalyani, cowpea entries UPC-95-1, IFC-9503, IFC-9504 and CL-341 had less damage of insect-pests and rice bean entries BC-2 and BC-3 were comparatively free from insect pests.

In lucerne, this year severe incidences of lucerne weevil during the month of January-February and spotted alfalfa aphid during February-March provided an opportunity to screen the germplasm material under field conditions. Six hundred and ninty five lines consisting of material from Gujarat, Punjab, Rajasthan, Tamilnadu and U.P., exotic material and individual plant progenies and 210 individual plant selections were scored for weevil and aphid damage.

Estimation of losses in intercropping of cowpea with maize and sorghum

A factorial experiment with insect pest

protected crop with insecticides and unprotected crop as main treatment and five combinations of crops *viz.*, maize, sorghum, cowpea as solo crop and cowpea in combination with maize and sorghum was laid out. The egg laying preference of the shootfly did not differ in any of the treatments however, eggs laid/plant varied from 1.82 to 2.50 (Table 23). The per cent dead hearts caused by the shoot fly, leafhoppers, number of holes by the flea beetle and per cent leaf damage by defoliators differed significantly between treated and untreated treatments. The green fodder yield was 21.367 t/ha in treated plots as compared to 16.367 t/ha in untreated plots showing an increase of 36.9% yield. The per cent dead hearts were highest in sorghum (5.683) and least in maize (2.610). Intercropping of sorghum and maize with cowpea lowered the insect incidences in cowpea crop as cowpea lowered the insect incidences in cowpea crop as compared to solo crop of cowpea. Sorghum crop lowered the number of holes by flea beetle and per cent leaf damage by defoliators by 22.14% and 16.26% respectively and maize crop by 11.95% and 7.72% respectively. The interaction between the insecticides treatment and crops were not significant.

Table 23 : Insect incidences in solo and intercropped cowpea in treated and untreated plots

Treatments	Shootfly		Jessids/ 10 leaves	Holes/ leaf	% leaf damage	Yield t/ha
	eggs	%dead				
Main treatment						
Treated	1.907	2.667	2.040	1.746	3.233	21.300
Untreated	2.117	5.502	5.661	7.672	18.089	16.367
F Test	N.Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
CD 5%	—	1.632	0.422	0.270	1.786	1.318
Sub Treatment						
Cowpea	—	—	4.647	5.220	11.553	20.667
Maize	1.850	2.610	—	—	—	19.833
Sorghum	2.500	5.683	—	—	—	19.833
Cowpea+Sorghum	1.880	4.632	3.205	4.050	9.103	20.667
Cowpea+Maize	1.817	3.412	3.701	4.857	11.327	16.583

1.4 Insect associated with non-leguminous forages and their management

(S.A. Faruqui and K.C. Pandey)

Insect pest parasite monitoring

Sorghum crop was infested by 14 pest species at different crop stage. The sorghum shootfly (*Atherigona soccata*), stem borer (*Chilo zonellus*), Sorghum ear head midge(*Contarinia sorghicola*) and ear head caterpillars(*Heliothis armigera*) and web worms were major species recorded. The shootfly incidences were recorded at 72% in some of the susceptible cultivars. *Trichogramma* sp., *Apanteles*

flavipens, *Bracon* sp., *Betheplectes* sp., *Tetrastichus* were recorded as parasites on these pests. *Coccinella* sp. and *Episyrphus* sp. were the predators recorded on aphids infesting sorghum and maize.

Screening for resistance

Different types of sorghum germplasm was screened for identifying sources of resistance towards major pests.

Out of 302 lines of sorghum received from ICRISAT, 108 entries were classified under highly resistant (0 Score), 61 (1 score), 76 (2 and 3 score), 31 (4 and 5 score) and 26 with infestation range of 6 and above groups in their screening for shootfly resistance (0-9 score). Some of the above referred entries showed multiple resistance to shootfly and anthracnose *viz.*, SPAN 94010, 94016, 94019, 94021, 94026, 94032, 94033, 94035, 94039 and 94040. Nine entries those showed resistance to shootfly and downy mildew were SPAM 94019, 94021, 94034, 94041, 94048, 94049, 94053 and 94054.

Out of 363 hybrid lines screened for resistance to shootfly reaction, lines M 60907A X IS3289, ICS13A X Piper Sudan, M 60956A X IS 1245, M 60957A X IS 2250, M 60967A X IS 14463, M 60967A X IS 1245, IS 296A X IS 1245 showed high degree of tolerance to the pest.

Forty five strains developed for single cut and eight for multicut were evaluated for pest reaction, Nos. 2077A x *S. lanceolatum* 2-12-2-3-1 and 4-6-1-2-3, 296 A x *S. virgotum* 2-4-3-1-1, 2-4-2-2, 1-1-7-1-2, 2077A x IS 13677, 2219A x Etawah-2, 3-2-3-4-1, 3-2-3-3-4, 6-1-2-1 and 20-1-2-2 and 2077 x IS13677-4-4-1-3 were found to be free from shootfly attack. Six promising strains in their final evaluation trial for single out system were identified as high to medium resistant *viz.*, 2077A x 5 *aethiopicum* 14-4-4-1, 2219A x I-1-3-1, 4-1-2-1, 4-1-2-3, 14-4-4-1 and 2219A x I-13-1 towards foliage pest.

1.6 Vesicular arbuscular mycorrhizal (VAM) fungi and nematode activities in forage production

(R.K. Jain and Pradeep Saxena)

Survey

About 50 soil and plant samples were asseyed for VAM and nematode association. Many weed species were found as good hosts for native VAM. *Glomus fasciculatum* and *G. aggregatum* were predominant species.

Field screening of Kinnow and *Ber* plantations for VAM association

Mycorrhizal colonization (45-65%) was recorded in all the plantations. The most common native specie was *G. fasciculatum*.

Relative mycorrhizal dependency in grass species

Out of nine grass species, *Cenchrus ciliaris* was found highly dependent on mycorrhizal association.

1.10 Nematode-fungi disease complexes and their management in selected forage legumes

(N. Hasan and R.B. Bhaskar)

Survey and surveillance

In lucerne fields, varying degree of wilt and downy mildew disease incidences, lesion nematode (*Pratylenchus zeae)*, root-knot nematodes (*Meloidogyne*) spp. and a fungal feeder nematode (*Aphelenchus avenae*) were found to be predominant with high population densities (95-2500/ 250 g soil) along with 2 pathogenic fungi i.e. *Fusarium* sp. and *Perenospora trifolii*.

A highly significant and positive correlation (r = 0.75, P 0.05, 0.01) between *P. zeae* and wilt disease caused by *Fusarium* sp. was observed. Moreover, when the total nematode population ranges of *P. zeae* and wilt disease index of lucerne were plotted against each other a linear relationship was observed. However, a negative correlation (r = 0.80) between *A. avenae* nematode population and wilt disease were also observed especially where the crops showed lesser wilt disease incidence. The frequency distribution pattern along with the mean values of total nematode population and wilt disease index of lucerne are presented in table 24 and 25.

Table 24 : Grouped data on *P. zeae* populations per 250 g soil and wilt disease index of lucerne under field conditions

Class limit	Frequency population	Mean Index	Disease
0-100	4	85	0.5
101-275	7	200	1.0
276-450	12	375	1.8
451-675	18	585	2.5
676-2000	30	1850	4.0

Coefficient of correlation (r = 0.75)

Table 25 : Grouped data on *A. avenae* populations per 250 g soil and wilt disease index of lucerne under field conditions

Class limit	Frequency population	Mean index	Disease
0- 95	3	85	4.0
96-150	5	128	3.2
151-275	10	235	2.5
276-800	15	765	1.0
801-2500	20	2450	0.4

Coefficient of correlation (r = -0.80)

During the second year of survey in case of cowpea and berseem root-rot disease complex, a significant and positive correlations (r = 0.79 and 0.90) between some major nematodes (e.g. *M. incognita, M. javanica and T. vulgaris*) and root-rot disease severity was observed. These results are on the similar lines of previous year survey. It appears that the presence of *P. zeae* in lucerne, *T. vulgaris* in berseem and *Meloidogyne* spp. in cowpea even in low to moderate population levels play an important role in increasing the wilt/root-rot disease severity of these crops. Moreover, the presence of *A. avenae* found to reduce the wilt disease of lucerne is of special interest and may be utilized in biological control by managing its population in field soil.

1.11 Predacious nematodes with reference to predator-prey relationships in forage crops

(M.I. Azmi)

Survey and taxonomy

Predacious nematodes were found in 70 to 90% samples from cowpea, sorghum, maize and lucerne fields. Their populations in relation to plant parasitic nematodes ranged from 3% to 12% (*Iotonchus monhystera* and *Mylonchulus minor* were predominant).

Laboratory observations

In case of predacious nematodes, *I. monhystera, M. minor, Discolaimium tausifi*, the two blastomeres formed after the first cleavage divided simultaneously and gave rise to four-celled condition. The embryo move for the first time during tadpol stage. Hatching occurred as a result of rupture of the shell. The gonad developed from two small genital primordia placed on each side of intestine. The germinal nucleus of primordium remained undivided until third moult.

Estimates of biotic potential i.e. intrinsic rate of natural increase were computed from the data generated on generation time and rate of egg production by individual female within the temperature range of 15°C to 33°C. These temperatures will be helpful in predicting the population regulation models of these predacious nematodes in integrated nematode management programme.

Predator-prey relationships

Agar inoculum test : This test was carried out at four starved conditions of predators, i.e. 0, 5, 10 and 15 days. Four days observations showed that the most preferable prey is the larvae of *M. incognita* followed by *P. zeae* and *A. avenae*, but these predators can be maintained on *Acrobeles* sp.

Soil inoculum test : Within 5 days approximately, 25 - 90% reduction in the population of *M. incognita* larvae and 10-73% reduction in the population of *P. zeae* were recorded when 5 to 15% of any of the three predators were inoculated.

Biology and behaviour

Culture : Predacious nematodes *I.*

monhystera, M. minor and *D. tausifi* were cultured in (1) 5% soil extract + 1% beef extract (2) humus filter (1% w/w) and (3) dung filter (1% w/w). Humus filter was best medium as more multiplication of these predacious nematodes occurred.

Pot experiment

Pot experiments were conducted by using *I. monhystera* and *M. minor* as predator and *M. incognita* on cowpea and *P. zeae* on maize as target nematode. Remarkable reduction in the population were recorded resulting in 40-55% increase in the plant weight.

1.12 Population dynamics and augmentation of beneficial soil insects and mites in forages

(Sharmila Roy and S.A. Faruqui)

At both the sites silvipasture and *Leucaena* systems, the collembola and acarines populations were found significantly correlated with each other and negatively correlated to the soil temperature at 5 cm. depth. In leucaena plantation the populations were also found positively correlated with soil moisture and in silvipasture system negatively correlated to air temperature. The population of both the fauna reached their peak during January - February in silvipasture system and during August - September in leucaena plantation.

The dipterans at the leucaena system reached at their maximum population during August while in silvipasture system during July. The dipterans were found positively correlated with the precipitation in both the systems.

In another experiment on IPM of sorghum + cowpea/ berseem + Chinese cabbage, maize + cowpea forage production system, no significant effect of various protection measures, on soil arthropods was observed.

1.13 Insects associated with *Sehima-Heteropogon* dominated grassland and their management

(N.K. Shah)

Prevalence, succession and seasonal abundance of insect pests

In *Sehima-Heteropogon* dominated grassland community the incidences of grasshoppers were a major pest problem. The important species involved were *Crotogonus* sp. *Hieroglyphus nigrorepletus* Bol., *Acrida exaltata* Wlk. and *Catantops pinguis* Stol. The damage were noticed from June-November. *Crotogonus* was first in the succession followed by *H. nigrorepletus, A. exaltata* and *C. pinguis.*

During March-April, the incidences of termite (*Odentotermes obesus* Ramb. was noticed on the ground flora particularly on the tussucks of perennial grasses. Aphid (*Hysteroneura setariae* Thomas) and mealy bugs were also noticed although in traces on *Grevia flavicense* during August-September. Various species of *Zizyphus* present in the community were found to be damaged by fruitfly during February-March.

Assessment of avoidable losses due to insect pests

The average leaf damage in unprotected plots was 7.09 per cent higher than that in insect protected plots. The average leaf damages were 2.02 and 9.11 per cent respectively (SE = 0.56) in the protected and unprotected plots. The average green forage yield in the protected plots increased by 20.87 per cent over unprotected plots.

1.14 Analysis of factors affecting resistance to major diseases of Stylo and Lucerne

(Pradeep Saxena and S.T. Ahmad)

Identification of pathogens

Anthracnose disease is a major problem of Stylo. The pathogen is identified as *Colletotrichum gloeosporioides*.

The downy mildew is caused by *Perenospora trifolii*. The infected plants, showed yellow spots on the leaf. The area below the leaf spots was covered with cottony white mass of pathogen. Mycelium is branched, intercellular with branched haustorium. Conidiophore dichotomously branched and emerged from Stoma. Conidia hyaline ovate and measured as 24-29 x 18-21 µm. Whereas 00 spores were 20-30 µm in diameter.

Screening

Seventeen species of *Stylosanthes*, 28 lines of *S. hamata*, 6 lines of *S. scabra* were screened against the anthracnose under natural conditions. All lines and species showed resistance to varying degree against the disease.

Similarly, 588 lines of lucerne were screened against downy mildew disease. The lines were categorized in six groups and CP-34, CM-20, CH-1, CV-41, CV-37, E-47, E-45, G-30, H-11 and H-55 lines showed resistance under field conditions. Besides this, 212 selected single plant progenies and 19 varieties were also screened for their reactions, date are in process.

2.1 Integrated Pest Management for Intensive Forage Production in Sorghum + Cowpea - Berseem + Japan Sarson -Maize + Cowpea System

(S.T. Ahmad, K.C. Pandey, R.B. Bhaskar and M.I. Azmi)

During *kharif*, the insect incidences in this three factor experiment revealed that main soil treatments burning and addition of *Neem* cake @ 15 q/ha did not influence the incidences of leafhoppers in the crop (Table 26). The other factor of seed treatment with Carbafuron and Bevistine + Thiram or Trichoderma lowered the leafhopper population in cowpea crop up to 20 days (14.26 to 5.98), however, at 45 days its influence was not noticed. The third factor of spray with *Neem* seed kernal extract @ 3% significantly reduced the hopper population (4.93/plant) as compared to unsprayed (14.86/plant).

The per cent leaf damage by defoliators ranged from 2.90 to 12.91 in 20 days crop

Table 26 : Incidences of insect-pest damage in cowpea

Treatments	Leafhoppers/plant		% Leaf damage	
	20 days	45 days	20 days	45 days
Soil Treatment				
Untreated	15.32	15.65	6.21	9.26
Treated	15.08	16.38	6.83	9.93
Neem cake	16.34	17.27	6.42	9.80
Seed Treatment				
Untreated	14.86	15.93	6.38	9.77
Carb+Bavi+Thiram	6.73	14.39	6.82	9.76
Carb+Trichoderma	5.98	15.28	6.26	9.46
Sprays				
Unsprayed	14.26	14.86	12.91	17.51
B.thuringiensis	13.92	13.93	3.64	6.12
Neem Seed Kernal	0.84	4.93	2.90	4.93

and 5.35 to 17.51 in 45 days crop. Both the main treatments of soil and seed did not influence the damage. The sub-treatment of both the sprays i.e., *B. thuringiensis* and *Neem* seed kernal reduced damage by defoliators from 17.51% to 6.12% and 5.35 respectively.

Sorghum crop was free from insect pest damage. In *rabi* crop of berseem + mustard none of the treatments showed major problem of insect-pests.

DIVISION OF RURAL ECONOMICS AND BIOMETRICS

REB-1 : ANALYSIS OF FARM MANAGEMENT AND ECONOMICS OF FORAGE PRODUCTION SYSTEM AND UTILIZATION

Commercial seed production in Verano stylo (*Stylosanthes hamata*)- economic considerations

(R.P. Singh, R.A. Singh and P.K. Jayan)

The information collected through survey and case studies about the factors, practices and yield potentiality of Verano stylo applicable to four different production sites (Jhansi, Dharwad, Kolar and Anantpur) have shown that there are significant seed yield variations as influenced by latitude, rainfall, temperature, plant height and growth as well as the physical texture of the ground surface. The most economical stylo seed production tract was found located in between 13° - 14°5'N latitude and 76° - 77°E longitude in the country, having the yield potentiality of more than 1500 kg/ ha at the economic production cost of Rs.13.75/kg. This enterprise was found offering employment opportunity to the extent of 450 man days/ha.

There is need to upgrade the production technology with the inclusion of seed treatment, use of rhizobium culture, application of phosphatic and potassic fertilizers, introduction of seed quality and certification aspects, organization of service cooperative for establishing community centre and extending mechanical contravenes and marketing facilities to the farmers.

1.7 Socio-economic analysis of NWDB project for Bundelkhand region- sites Ambabai and Chopra

(R.A. Singh and Sandeep Saran)

Cost of cultivation of various crop demonstrations conducted during *rabi* and *kharif* seasons at the farmers' field in the project sites of Ambabai, Lakara and Karari (Jhansi) are presented in table 27 and 28.

The labour cost constituted the major component of the total cost ranging from 20-35 per cent. Since majority of this labour comprised of family labour, farmers did not realize this cost and hence it turned out to be an invisible cost. Another major cost component particularly for the crops grown for fodder purposes was bullock labour with its share ranging from 20-35 per cent of total cost. Bullock labour was mainly used for transporting the green fodder from the points of production to the points of consumption and transaction. Seed and fertilizer costs remained well below 15 per cent for most of the crops. *Sem* and MP Chari were grown without any fertilizers. Similarly hardly any fertilizers/FYM were applied for Jowar. However, in the rest of the crops FYM was applied with the exception of soybean + maize where only fertilizers

Table 27: Economics of cultivation of various crops in Ambabai, Karari and Lakara villages during 1995-96

(in Rs/ha)

Cost	Items	Sem (Green fodder)			M.P. Chari			Groundnut + Maize (GM)		
		Ambabai	Karari	Lakara	Ambabai	Karari	Lakara	Ambabai	Karari	Lakara
Labour Cost										
	Human Labour	2000.00	2058.82	2333.33	2770.83	2406.25	2625.00	6008.33	6781.25	6825.00
		29.62%	30.99%	29.28%	36.21%	37.71%	33.09%	31.04%	33.81%	32.63%
	Bullock Labour	800.00	705.88	1066.67	2000.00	1000.00	1636.36	5600.00	5600.00	5600.00
		11.85%	10.63%	13.38%	26.14%	15.67%	20.63%	28.93%	27.92%	26.78%
	Tractor Labour	-	-	-	-	-	-	-	-	-
Material Cost										
	Seed	1200.00	1235.29	1200.00	200.00	200.00	200.00	2440.00	2395.00	2620.00
		17.77%	18.60%	15.06%	2.61%	3.13%	2.52%	12.60%	11.94%	12.53%
	Fertilizer	-	-	-	-	-	-	1300.00	1230.00	1300.00
								6.72%	6.13%	6.22%
	FYM	457.14	352.94	533.33	333.33	500.00	636.36	1000.00	1000.00	1000.00
		6.77%	5.31%	6.69%	4.36%	7.84%	8.02%	5.17%	4.99%	4.78%
	Irrigation	-	-	-	-	-	-	-	-	-
Overheads		50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
SUBTOTAL		4507.80	4403.59	5183.97	5354.85	4156.89	5148.36	16399.17	17057.10	17395.83
Interest on working capital @12% p.a.		270.47	264.22	311.04	321.29	249.41	308.90	983.95	1023.43	1043.75
Land Rent		1975.00	1975.00	2475.00	1975.00	1975.00	2475.00	1975.00	1975.00	2475.00
Total Cost		6753.27	6642.80	7970.01	7651.14	6381.31	7932.26	19358.12	20055.52	20914.58
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Production										
	Main Yield	334.29	388.24	333.33	441.67	500.00	450.00	535+286	675+364	553+461
	Main Product	8357.25	9705.88	8333.33	11041.67	12500.00	11250.00	26749.95	25312.50	27649.95
	By Product	-	-	-	-	-	-	-	-	-
Gross Returns		8357.25	9705.88	8333.33	11041.67	12500.00	11250.00	26749.95	25312.50	27649.95
Net Returns		1603.98	3063.08	363.32	3390.52	6118.69	3317.74	7391.83	5256.98	6735.37
B-C Ratio		0.24	0.46	0.05	0.44	0.96	0.42	0.38	0.26	0.32

Table 28 : Economics of cultivation of various crops in Ambabai and Choprà villages during 1994-95

Crops —> Cost Items	Mustard (Varuna)	Mustard (Rohini)	Berseem (Wardan) Ambabai	Berseem (Wardan) Chopra	Gram *(Avrodhi)*	Gram (K-850)	*Til* (T-4)	*Urd* (P-435)	Maize *(Naveen)*
Labour Cost									
. Human Labour	1385.19	2416.56	6199.47	6095.83	1628.12	1670.06	1128.00	1254.00	2445.00
	21.30%	33.96%	36.17%	38.84%	20.57%	20.14%	30.19%	28.82%	37.85%
Bullock Labour	355.21	567.61	1188.83	1137.50	750.00	806.69	228.00	444.00	696.00
	5.46%	7.98%	6.94%	7.25%	9.47%	9.73%	6.10%	10.20%	10.77%
Tractor Labour	729.15	250.00	212.77	-	-	-	133.00	101.00	-
	11.21%	3.51%	1.24%				3.56%	2.32%	
Material Cost									
Seed	106.02	95.50	1851.06	1772.73	1547.25	1619.22	101.00	249.00	197.00
	1.63%	1.34%	10.80%	11.30%	19.54%	19.53%	2.70%	5.72%	3.05%
Fertilizer	642.68	671.64	1315.81	1340.50	846.81	964.80	312.00	434.00	1134.00
	9.88%	9.44%	7.68%	8.54%	10.70%	11.64%	8.35%	9.97%	17.55%
FYM	-	-	1638.30	583.33	-	-	-	-	-
			9.56%	3.72%					
Irrigation	508.33	303.41	1851.06	1962.50	288.00	353.20	-	-	-
	7.82%	4.26%	10.80%	12.50%	3.64%	4.26%			
Overheads	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
SUBTOTAL	3776.58	4354.72	14307.30	12942.39	5110.18	5463.97	1952.00	2532.00	4522.00
Interest on work capital @12% p.a.	226.59	261.28	858.44	776.54	306.61	327.84	117.12	151.92	271.32
Land Rent	2500.00	2500.00	1975.00	1975.00	2500.00	2500.00	1667.00	1667.00	1667.00
Total Cost	6503.17	7116.00	17140.74	15693.93	7916.79	8291.81	3736.12	4350.92	6460.32
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Production									
Main Yield*	956.67	621.59	80213.00	85833.00	906.25	1095.93	281.97	445.75	1229.00
Main Product	9791.25	6268.18	24063.83	25750.00	9062.50	10959.30	7860.00	8131.00	5603.00
By Product	140.14	84.73	-	-	387.50	494.19	59.00	202.00	700.00
Gross Returns	9931.39	6352.91	24063.83	25750.00	9450.00	11453.49	7919.00	8333.00	6303.00
Net Returns	3428.22	-763.09	6923.09	10056.07	1533.21	3161.68	4182.88	3982.08	-157.32
B-C Ratio	0.53	-0.11	0.40	0.64	0.19	0.38	1.12	0.92	-0.02

were applied. Further all the crops were grown as rainfed crops with no irrigation.

Land rent was another major invisible cost for the farmers. Since most of the farmers owned their lands, they paid land revenue which was quite nominal as compared to the land rent. Cultivation of soybean + maize for green fodder resulted in losses (imputed) to the farmers owing to high proportion of labour cost. Jowar yielded quite good returns. Rest of the crops yielded moderate to good B-C ratios indicating fairly good returns over cost-C.

Berseem and maize crops were found to be the most labour intensive crops whereas gram required relatively less labour (Table 28). Bullock labour component remained less than 10 per cent of total labour cost for almost all the crops which was mainly due to the fact that bullock labour was used predominantly for pre-sowing operations. The extent of mechanization was found low as indicated by the lower share of tractor labour in total cost.

Of the two varieties of mustard, 'Varuna' was found superior to 'Rohini' with a B-C ratio of 0.53 as compared to -0.11 for the latter. The berseem variety, 'Wardan' was found performing well at farmers' field in both the villages *viz.*, Ambabai and Chopra. The gram variety 'K-850' turned out to be superior to 'Avrodhi' economically as indicated by their respective B-C ratios.

Til, maize and *urd* were the major *kharif* crops in these villages. Of these, *til* was found to be the most profitable. Usually, *til* - a high value crop, was grown on marginal and sub-marginal lands and required low cash and other inputs. Therefore, *til* was one of the most popular *kharif* crops in the region followed by *urd*. Like *til*, *urd* also required little inputs and was grown on marginal lands without any irrigation. Though, maize was also grown in the region, the same indicated negative B-C ratio showing little economic viability of the crop at farmers' field.

1.6 Impact of integrated development of Lakara-Karari watershed on rural economics

(R.A. Singh)

Land distribution

The total agricultural land in the Lakara-Karari watershed area increased from 1411.4 ha in 1987 to 1483.41 ha in 1994 registering an increase of over five per cent (Table 29). During the same period, the irrigated area increased by 51.85 per cent whereas the unirrigated area increased by about five per cent. As a result of the operation of watershed development project, there has been a perceptible rise in the water table and the number of wells have almost doubled in the area. This has been one of the reasons for increase in the irrigated area. Further, the cultivable wasteland in this area also registered a steep decline, which can be attributed to the development and operation of the watershed development project.

Table 30 shows that there have been perceptible changes in the cropping pattern over a period of eight years. Total

Table 29 : Land distribution - percentage change during the period 1987 to 1994

Land class	Rund Karari	Lakara	Karari	Total
Total Agricultural land	19.60	1.35	0.88	5.10
Irrigated land	25.61	71.59	46.28	51.85
Unirrigated land	97.08	-22.25	-16.04	5.01
Cultivable Waste land	-67.75	-79.89	-64.61	-70.48

Table 30 : Impact of watershed development activities on cropping pattern in village Lakara, Jhansi

(in ha)

Crop	1986	1989-90	1991-92	1994
Wheat	192.94	155.30	213.82	290.24
Wheat+mustard	-	35.06	-	-
Gram	207.31	50.21	95.14	89.37
Pea	-	-	7.00	80.77
Berseem	5.11	12.00	15.90	13.70
Barley	2.23	13.94	25.21	23.65
Mustard	9.71	3.00	23.49	81.15
Alsi	4.45	-	-	-
Sehuwar	6.27	9.71	10.45	4.67
Gram+mustard	8.40	6.07	27.26	-
Rabi Total	436.41	285.29	441.48	581.05
Urd	1.09	7.20	7.83	19.71
Maize	1.09	3.89	4.75	7.57
Til	14.55	21.46	26.29	34.38
Sorghum (grain)	76.18	56.37	49.89	41.78
Sorghum+*arhar*	23.27	17.45	20.04	-
Sorghum (fodder)	-	21.46	23.66	36.88
Moong	-	2.61	12.78	16.65
Urd+til	-	4.80	13.20	-
Groundnut	-	8.60	10.89	49.69
Soybean	-	-	-	23.56
Kharif Total	116.19	143.78	158.46	230.22

rabi area has increased from 436 ha to 581 ha with most of the area coming from rejuvenation of the wastelands in the project site.

During *kharif* season also, such changes in the cropping pattern were quite visible. The total area under *kharif* crops has almost doubled as a result of the operation of the watershed development project.

REB-2 : BIOMETRICAL STUDIES IN FORAGE PRODUCTION AND UTILIZATION

2.2 Studies on sampling in forage crops for evaluating the optimum sample size for yield estimation

(Ashok Kumar and D.P.Handa)

Plot sampling technique in lucerne for technology verification experiments

The optimum sample size of the number of plots of different size and shapes were determined for plot sampling technique under technology verification experiments on lucerne grown under uniform conditions at IGFRI, Jhansi. The sampling technique used was Simple Random Sampling without replacement and the sample sizes were obtained at various sampling errors as a percent of population mean and are presented in table 31(a), 31(b) and 31(c) corresponding to 1st, 2nd and 3rd cuts respectively. In addition to this, some regression models (*response surfaces*) like Linear, quadratic, cubic and logarithmic etc. have been developed for prediction of per cent sampled area to be harvested for forage yield estimation of lucerne with respect to plot size(ultimate sampling units). It was observed that, 10.60%, 7.73% and 9.28% sampled area consisting different plots of sizes $2m^2$(1m x 2m or 2m x1m) each selected with Simple Random Sampling without Replacement technique, will be sufficient to be harvested for yield estimation of lucerne, respectively during 1st, 2nd and 3rd cut at 10% sampling error.

For predicting percent sampled area to be harvested for yield estimation of lucerne with respect to size of sample plots,a Quadratic Response was observed good fit at both 5 % and 10 % sampling error and are as under :

Cutting I

(i) at 5 % error :

$$\mathbf{PA} = 27.6784 + 3.7004\ \mathbf{L} - 0.0726\ \mathbf{L^2} + 5.1754\mathbf{B}$$
(0.2688) (0.0065) (0.4101)

$$- 0.1289\ \mathbf{B^2} - 0.0533\ \mathbf{L \times B}$$
(0.1289) (0.0141)

$\mathbf{R^2} = 0.90$

(ii) at 10 % error :

$$\mathbf{PA} = -0.4668 + 3.5652\ \mathbf{L} - 0.0760\ \mathbf{L^2} + 4.6254\ \mathbf{B}$$
(0.2328) (0.0056) (0.3552)

$$-0.1057\ \mathbf{B^2} + 0.0078\ \mathbf{L \times B}$$
(0.0127) (0.0122)

$\mathbf{R^2} = 0.94$

Table 31(a) : Number of sample plots of various sizes and shapes to be harvested for yield estimation of lucerne grown under technology verification experiments (cutting I)

(BASED ON DESIRED VARIATION AS A % OF POPULATION MEAN)

Plot Size		$1m^2$	$2m^2$		$3m^2$		$4m^2$		
Plot	Shape	1mx1m	1mx2m	2mx1m	1mx3m	3mx1m	1mx4m	2mx2m	4mx1m
		864*	432*		288*		216*		
	5%	198	139	140	109	111	89	96	95
		(22.94)	(32.16)	(32.35)	(37.87)	(38.65)	(41.32)	(44.24)	(44.01)
	10%	60	46	46	38	39	32	36	35
		(6.93)	(10.60)	(10.68)	(13.22)	(13.61)	(14.97)	(16.55)	(16.42)
	15%	28	22	22	18	19	16	18	17
		(3.20)	(5.00)	(5.05)	(6.34)	(6.54)	(7.25)	(8.10)	(8.03)
	20%	16	12	13	11	11	9	10	10
		(1.83)	(2.88)	(2.90)	(3.67)	(3.79)	(4.21)	(4.73)	(4.68)
	25%	10	8	8	7	7	6	7	7
		(1.18)	(1.86)	(1.88)	(2.38)	(2.46)	(2.74)	(3.08)	(3.05)
	30%	7	6	6	5	5	4	5	5
		(0.82)	(1.30)	(1.31)	(1.66)	(1.72)	(1.92)	(2.16)	(2.14)

Table 31(b) : Number of sample plots of various sizes and shapes to be harvest for yield estimation of lucerne grown under technology verification experiments (cutting II)

(BASED ON DESIRED VARIATION AS A % OF POPULATION MEAN)

Plot Size		$1m^2$	$2m^2$		$3m^2$		$4m^2$		
Plot	Shape	1mx1m	1mx2m	2mx1m	1mx3m	3mx1m	1mx4m	2mx2m	4mx1m
		864*	432*		288*		216*		
	5%	155	108	112	79	86	65	76	76
		(17.94)	(25.10)	(25.88)	(27.43)	(29.84)	(30.11)	(35.08)	(35.09)
	10%	45	33	35	25	28	21	26	26
		(5.18)	(7.73)	(8.03)	(8.63)	(9.61)	(9.72)	(11.90)	(11.91)
	15%	21	16	16	12	13	10	12	12
		(2.37)	(3.59)	(3.74)	(4.03)	(4.51)	(4.57)	(5.66)	(5.67)
	20%	12	9	9	7	7	6	7	7
		(1.35)	(2.05)	(2.14)	(2.31)	(2.59)	(2.62)	(3.27)	(3.27)
	25%	7	6	6	4	5	4	5	5
		(0.87)	(1.32)	(1.38)	(1.49)	(1.67)	(1.69)	(2.12)	(2.12)
	30%	5	4	4	3	3	3	3	3
		(0.60)	(0.92)	(0.96)	(1.04)	(1.17)	(1.18)	(1.48)	(1.48)

Table 31(c): Number of sample plots of various sizes and shapes to be harvested for yield estimation of lucerne grown under technology verification experiments (cutting III)

(BASED ON DESIRED VARIATION AS A % OF POPULATION MEAN)

Plot Size		$1m^2$	$2m^2$		$3m^2$		$4m^2$		
Plot	Shape	1mx1m	1mx2m	2mx1m	1mx3m	3mx1m	1mx4m	2mx2m	4mx1m
		864*	432*		288*		216*		
	5%	173 (20.02)	125 (29.04)	125 (29.04)	96 (33.26)	101 (35.09)	77 (35.46)	86 (39.74)	83 (38.61)
	10%	51 (5.89)	40 (90280)	40 (9.28)	32 (11.08)	34 (11.90)	26 (12.08)	31 (14.15)	29 (13.59)
	15%	23 (2.71)	19 (4.35)	19 (4.35)	15 (5.24)	16 (5.67)	12 (5.75)	15 (6.83)	14 (6.53)
	20%	13 (1.54)	11 (2.49)	11 (3.02)	9 (3.27)	9 (3.27)	7 (3.32)	9 (3.96)	8 (3.78)
	25%	9 (0.99)	7 (1.61)	7 (1.61)	6 (1.95)	6 (2.12)	5 (2.15)	6 (2.57)	5 (2.45)
	30%	6 (0.69)	5 (1.12)	5 (1.12)	4 (1.37)	4 (1.48)	3 (1.50)	4 (1.80)	4 (1.72)

Figures in parentheses are approximate sampled area to be harvest for the corresponding size and shape of plots.
* Total number of population units.
# Source of data : Secondary data from the project "Uniformity Trials on Forage Crops " at Jhansi.

Cutting II

(i) at 5 % error :
PA = 22.6544 + 3.1120 **L** - 0.0467 $\mathbf{L^2}$ +2.6677 **B**
(0.3212) (0.0077) (0.4901)

- 0.0545 $\mathbf{B^2}$ - 0.0569 **L x B**
(0.0176) (0.0169)
$\mathbf{R^2}$ = 0.82

(ii) at 10 % error :
PA = 5.7231 + 1.7148 **L** - 0.0185 $\mathbf{L^2}$ + 1.3984 **B**
(0.2624) (0.0063) (0.4004)

-0.0232 $\mathbf{B^2}$ - 0.0248 **L x B**
(0.0144) (0.0138)
$\mathbf{R^2}$ = 0.78

Cutting III

(i) at 5 % error :
PA = 23.1400 + 3.7640 **L** - 0.0736 $\mathbf{L^2}$ +4.7791 **B**
(0.2819) (0.0068) (0.4302)

- 0.1072 B^2 - 0.0639 **L x B**
(0.0154) (0.0148)
R^2 = 0.89

(ii) at 10 % error :
PA = 0.2560 + 2.9581 **L** - 0.0613 L^2 + 3.5472 **B**
(0.2155) (0.0052) (0.3289)

-0.0686 B^2 + 0.0078 **L x B**
(0.0118) (0.0113)
R^2 = 0.94

where,

PA = Percent sampled area
L = Length of the plot(sampling unit)
B = Breadth of the plot(sampling unit)

2.2.1 Statistical studies on rainfall pattern of Bundelkhand

(D.P. Handa and Ashok Kumar)

Effect of climatic variables for maize fodder yield

In continuation of the work done during previous year, the effect of one unit increase above average on weather parameters at different growth stages of maize crop (fodder) have been worked out and presented in table 32. Effect of one unit decrease below the average can be obtained by reversing the vertical scale.

Table 32 : Percent change in yield of fodder maize per unit increase in weather variable over its average value

Stage	Week No.	Week Sl.No.	Max. temp. (°C)	Min. temp. (°C)	Mean temp. (°C)	Humidity (%)	Rain fall	Rainy days (cm)
Germin-	28	1	-1.57	4.31	-4.72	-0.18	0.17	-18.72
ation	29	2	0.51	-4.21	-1.00	0.05	-0.10	-27.95
Knee-	30	3	0.14	1.30	-1.75	1.25	0.94	8.41
high	31	4	1.15	4.62	0.03	1.23	-0.31	-45.36
	32	5	3.67	3.50	4.21	2.68	0.01	-14.56
Tasseling	33	6	2.82	4.32	2.96	-1.15	-0.22	-10.93
& Silking	34	7	1.98	4.50	1.81	0.30	-0.05	-13.00
	35	8	-3.21	-2.62	-4.35	1.75	0.04	- 6.08
Milking	36	9	-4.35	- 8.55	-5.59	0.59	0.24	24.94
	37	10	-5.32	-6.97	-5.05	0.64	0.25	38.87
Maturity	38	11	-1.12	1.41	-7.15	1.49	-0.01	-22.24

Maximum temperature

It has shown beneficial effect from 4th week to 7th week of sowing, after that it indicated negative effect.

Minimum temperature

It has shown beneficial effect from 3rd week to 7th week and then 11th week.

Mean temperature

It has shown beneficial effect from 5th to 7th week. It has fluctuating effect.

Humidity

It has shown beneficial effect through out the period except 1st and 6th week.

Rainfall

It has shown good effect in 1st week and then 8,9 and 10th week i.e. from sowing week. It also has its fluctuating effect.

Rainy days

It has good effect during 3, 9 and 10th week of its sowing.

DIVISION OF AGRICULTURAL ENGINEERING AND POST HARVEST TECHNOLOGY

AE 1.2 Popularization of improved bullock drawn implements among farmers

(M.B. Tamhankar and Brajesh Singh)

The demonstration trials were conducted for different IGFRI developed bullock drawn implements in maize crop. The single row seed drill, two row seed drill and traditional method of sowing were used for sowing the crop. The sowing was done after bullock drawn country ploughing and disc harrowing. The trials were conducted in three different fields at the seed rate of 50 kg/ha with 30 cm row spacing. The average green matter yield of maize was 42.6, 41.1 and 35.8 t/ha for single row seed drill, two row seed drill and traditional method of sowing, respectively (Table 33).

The weeder cum mulcher was also tested at the farmers field and the average field capacity of the implement was found as 0.018 ha/hr with 71.8% field efficiency.

In the *rabi* season bullock drawn disc harrow and country plough was tested separately in the fields (3 operations) and compared in oat crop field. The average forage production was 360 q/ha in case of disc harrow, while it was 342 q/ha in case of country plough.

Besides this, these implements were tested for crops like black gram, green gram, lentil, seasamum in the *kharif* and

Table 33 : Effect of different sowing mechanism on production to maize fodder crop

Sowing Mechanism	Trial No.	Yield of green fodder t/ha
IGFRI single row seed drill	1	43.8
	2	41.8
	3	42.2
	Mean	42.6
IGFRI two row seed drill	1	40.8
	2	42.0
	3	40.5
	Mean	41.1
Traditional method	1	35.4
	2	37.0
	3	35.0
	Mean	35.8

wheat, gram, mustard in the *rabi*. The results showed increase in the production level for these crops. The farmers also showed interest to use these implements.

AE 1.3 Modification and improvement of hand operated tyre type pelleting machine

(P.D. Gupta)

Basic studies on tyre type seed-pelleting machine was conducted for making it power-driven. It was felt that machine should be provided with one HP; single phase, 220 volt 960 rpm electric motor. Electronic Ryder of 1000 watts, V-belt and pulley may be provided to control the speed of motor for testing at different speeds. The system for attaching electric motor was finalized.

AE 1.4 Development and testing of IGFRI grass seed harvester

(Brajesh Singh and M.B. Tamhankar)

Final prototype of improved IGFRI tractor front mounted grass seed harvester was tested for manufacturers/users view point. Work-ability of different adjustment mechanisms, their utility and limitations were critically examined. Critical components/mechanisms were identified and methods of their proper upkeep and maintenance was evolved. Based on this information and field testing experience during 1991-95, an operation manual of the machine containing general description, component description, technical specifications, adjustment mechanisms, mounting procedure, operation procedure, machine's limitations and guidelines for proper upkeep and maintenance/alignment of critical components was prepared for the benefit of the users.

AE 2.1.1 Studies on compaction, storage and transport of crop residues and grasses

(P.D. Gupta and V.C. Pachauri)

The grass and wheat bale samples of different moisture content, molasses and urea combination, under storage were analyzed for IVDMD %, crude protein and aflatoxin and results are given in table 36 and 37. From the analysis of IVDMD (%) for grass bale sample it was found that there is no significant difference in the result between bales stored with or without plastic cover. However, higher IVDMD % was noticed in case of treatment with or without polythene at moisture content 30%, molasses 0% and urea 2%.

Similarly, in case of wheat straw bale sample much effect was not noticed for IVDMD %, CP % and aflatoxin with or without polythene cover. However, good response of IVDMD % and CP % was noticed at moisture content 20% and 30%, molasses 10% and urea 2% with or without polythene cover (Table 34). Aflatoxin was not detected even after 12 months of storage.

Table 34 : IVDMD (%) of grass bale sample of different moisture content, molasses and urea combination under storage

Sl. No.	Treatments	IVDMD (%) 12 months
1.	Treatment with polythene moisture content 20%, molasses 0% and urea 0%	48.67
2.	Treatment without polythene moisture content 20%, molasses 0% and urea 0%	49.80
3.	Treatment with polythene moisture content 30%, molasses 0% and urea 0%	49.49
4.	Treatment without polythene moisture content 30%, molasses 0% and urea 0%	49.47
5.	Treatment with polythene moisture 30%, molasses 0% and urea 2%	57.75
6.	Treatment without polythene moisture content 30%, molasses 0% and urea 2%	58.29
7.	Treatment with polythene moisture content 30%, molasses 5% and urea 0%	46.73
8.	Treatment without polythene moisture content 30%, molasses 5% and urea 0%	46.00

The manual cum pedal operated baling machine was developed and was fabricated by M/S Mistri Engg. Works, Vapi, Gujarat. It has already been installed at Research Farm. Further testing, evaluation and improvement is in progress.

AE 2.1.2 Evaluation of feed-pelleting machine

(P.D. Gupta and V.C. Pachauri)

A new compact model of power operated

Table 35 : IVDMD (%), CP (%) and Aflatoxin analysis in wheat straw bale sample of different moisture content, molasses and urea combination under storage

Sl. No.	Treatments	IVDMD(%) Months 6	12	CP(%) 12	AFLATOXIN 12
1.	Treatment with polythene moisture content 20%, molasses 10% and urea 0%	41.59	42.42	5.85	ND
2.	Treatment without polythene moisture content 20%, molasses 10% and urea 0%	40.50		4.48	ND
3.	Treatment with polythene moisture content 20%, molasses 10% and urea 2%	47.06		7.48	ND
4.	Treatment without polythene moisture content 20%, molasses 10% and urea 2%	45.89		7.20	ND
5.	Treatment with polythene moisture content 30%, molasses 10% and urea 0%	40.91	44.42	4.71	ND
6.	Treatment without polythene moisture content 30%, molasses 10% and urea 0%	41.50	45.50	4.70	ND
7.	Treatment with polythene moisture content 30%, molasses 10% and urea 2%	47.54	44.29	6.50	ND
8.	Treatment without polythene moisture content 30%, molasses 10% and urea 2%	47.19	45.40	6.17	ND

feed-pelleting machine driven by 5 HP electric motor coupled with the machine was developed. The fabrication work was completed by M/S New Industries Co-orporation, Gwalior. Two such machines were fabricated and supplied by the manufacture to Birla Agricultural University, Ranchi and Himachal Pradesh Agricultural University, Palampur. Performance Test reports are still awaited.

DIVISION OF EXTENSION AND TRAINING

EXT-1 : ADOPTION AND DIFFUSION OF FORAGE INNOVATIONS AND FEED BACK INFORMATION

1.7 Participatory research at farmers field through participatory rural appraisal (PRA)

(Maharaj Singh, R.N. Dwivedi and P.S. Tomer)

PRA exercises were carried out with the farmers to collect the existing base resource information.

Out of trees grown for timber, fodder, fuelwood and fruits, farmers showed first preference for *shisham, kardhari, chheula* and lemon trees respectively.

As regard crops, the first preference of the farmers was for groundnut in *kharif* and wheat in *rabi* seasons. The most preferred crops were tomato among vegetables and berseem among fodder crops.

Farmers expressed that groundnut gets infested mostly with cutworms, wheat with termites and smut, gram with cutworms and mustard with aphids.

Out of the grass growing locally (*Bagsua, Muchhauri, Gandola, Gunia, Phulkara, Doob*), their preference was for *Bagsua, Machhauri* and *Phulkara* grass.

Farmer's perception about feeds and fodder given to animals and their common diseases was noted.

Different farm operations involved more drudgery of farm women while least drudgery was in cooking and other household works.

EXT-2 : EVALUATION OF FORAGE FARMING SYSTEMS AT FARMERS FIELD

(P.S. Tomer, S.T. Ahmad, R.N. Dwivedi, Maharaj Singh, M.B. Tamhankar and R.V. Singh)

Studies continued with three categories of farmers (large, medium and small) replicated at two sites (Sakrar and Awas) continued.

The improved technologies were introduced in the previous years and fallow lands were utilized for fodder production. The wasteland area was put under silvipasture and hortipasture systems. *Zizyphus numularia* was improved by budding with improved varieties of *ber* (Umran and Bararasi Karka). This practice was successful and farmers were very keen to adopt it.

The new varieties like SSG-855 of multicut sorghum, NP-3 and IGFRI-450 of cowpea, Bundel-1 and Bundel-2 of guar, Wardan of berseem and JHO 822 and JHO 851 of oats, provided to farmers, performed well.

Tomato (Hybrid and Pusa Rubi) and sugarcane (Co 1148) were introduced at

Awas site which performed well and proved income generating. Critical inputs for plant protection and weed control measures were also provided.

As compared to base year, the intensity of cropping increased from monocropping to double cropping. The increase in the yield of food, fodder and cash crops was almost double in all the seasons. The over all fodder availability in terms of green and dry at both the sites increased appreciably over the base year.

EXT-3 : TECHNOLOGY ASSESSMENT AND REFINEMENT THROUGH INSTITUTIONAL - VILLAGE LINKAGE

(P.S. Tomer, R.N. Dwivedi, Maharaj Singh, Purshottam Sharma, Rakesh Kumar and Mahavir Singh)

The team selected the villages namely Ghisauli, Bagora and Badora. Mobilization of farmers has been made and the rapport with the farmers has been established. The PRA exercises have been carried out in all three villages. In PRA exercises, historical time lime, crop and animal time limes, matrix of crop varieties and preferences of farmers and other base resources have been collected.

TRANSFER OF TECHNOLOGY

Training programmes

The following training programmes were organized :

Sl. No.	Title of Training and Sponsoring Agency	Dates	No. of Participants
1.	XV NARP training on Agro-forestry, Forage Production and Animal Nutrition sponsored by ICAR.	April 1-29, 95	20
2.	FAO/R Training on Forage Production for Nepal Forage Officers sponsored by Nepal Govt.	Aug. 17-26, 95	05
3.	MOA Training on Fodder Production for State Govt. Officers sponsored by Directorate of Extn., MOA Govt. of India.	Oct. 5-12, 95	16

4.	Indo-UK Training on PRA at Dahod for Institute Scientists sponsored by British Council.	Oct. 29 - Nov. 3, 95	10
5.	RVC Centre Meerut Training on Fodder Production for Military Officers.	Feb. 13-14, 96	09

Demonstrations

Thirteen field demonstrations on multicut sorghum during summer, 27 field demonstrations on jowar + cowpea during *kharif* and 37 field demonstrations on berseem and oats during *rabi* were conducted at farmers field in the villages around Jhansi, Datia, Shivpuri, Tikamgarh, Bulandshahr, Ghaziabad, Meerut and Gurgaon district. Besides, 5 Front line demonstrations on mustard and linseed crops were also conducted.

Demonstrations on silvipasture, agroforestry, hortipasture systems on farmers field as well as at FD Block were conducted. The total number of these perennial system demonstrations was 25. Thus, total Demonstrations laid out were 107.

Twenty field demonstrations on hybrid napier No. 6 and guinea grass were conducted and are being maintained at Patha, Rajpura, Uldan, Imlia, Magarwara, Pachwara, Gahra and Ghurat village of Bangra block. Besides, few demonstrations on hybrid napier and setaria grass were laid out near Delhi.

Collaborative programmes with state soil conservation department

Tejpura, Gahra and Pachwara hills cover about 30.19 ha, 83.75 ha and 158.0 ha, respectively. These hills, revegetated earlier with various grasses, legumes and fodder trees, were protected and maintained in collaboration with U.P. State Soil Conservation Department.

The fodder from these sites was allowed to be cut by the local farmers. The quantity of fodder was not worked out.

Nine check dams, 14 earthen bundhies and water harvesting bundhies were protected by planting para grass on the lower slopes and *Cenchrus ciliaris*, kans and khas on upper slopes.

Both sides of Kharya Nala planted earlier with para grass on the lower side and hybrid napier, *Cenchrus ciliaris* and *Dichanthium annulatum* on upper sides, established well.

Farmer's Mela/day

Two *Kisan Mela* one in *kharif* on Oct. 10, 1995 and another in *rabi* on Feb. 13, 1996

were organized. In each *Kisan Mela* a large number of farmers including extension workers and NGO's participated. After the field visit, the stalls erected by different organizations were shown and then buzz session was arranged in which farmers, extension workers and scientists interacted.

Kisan Gosthi organized

Two *Kisan gosthies* one at Chhapar on 11th July 95 and another at Ghisoli on 15th November 1995 were organized. Institute also participated in two *Kisan Gosthies* organized by the NRCAF and one *Gosthi* organized by the Department of Horticulture.

Exhibition stalls

At the following occasions stalls depicting IGFRI latest technology were erected :

NRCAF *Kisan Diwas*	on 14.09.95
IGFRI *Kisan Diwas*	on 10.10.95
IGFRI *Kisan Mela*	on 13.02.96
NRCAF *Kisan Mela*	on 22.2.96
Narain Bagh *Pushap* Pradarshani	on 24-25 Feb., 96
Bundelkhand *Vikash* Pradarshani	from 21 Feb. to 29 March, 96

Mahila Diwas (women in agriculture day)

It was organized on 4th December 1995 at Badora village in which a large number of farm women participated and interacted with specialists.

Visitors

Sixty seven groups consisting 1800 farmers, extension workers, development people, students and press reporters from different places of the country as well as from abroad were taken round the farm and out reach programmes.

Transfer of technology through letters and pamphlets

Five hundred forty four quarries of the farmers, extension workers, state officers and NGO were replied by giving suited advise and providing extension literature.

Radio/TV talks

More than a dozen TV talks have been delivered from Lucknow and Delhi and more than two dozen Radio talks from Chhatarpur and Jhansi Stations have been broadcasted.

FARMING SYSTEM RESEARCH PROJECT

PRODUCTION, UTILIZATION AND SUSTAINABILITY OF FOOD-FORAGE FARMING SYSTEM FOR RAINFED AREAS

Arable food-forage production systems for small farmers with varying resource levels under irrigated conditions

(K.C. Sharma)

Three cropping systems *viz.*, groundnut-wheat + mustard, *urd* bean - wheat + mustard and maize (cob) - berseem were evaluated under two resource levels (farmers and improved). In the second year of the experiment (*rabi* season), weed populations and its dry weights were undertaken at harvest in wheat + mustard plots only. A total 158 weeds/m^2 and dry weight 56.9 g/m^2 were recorded under farmers level as against only 74.5/ m^2 and 23.4 g/m^2 in improved practices. The grain and straw yield of wheat, when preceded by urd bean was 10.5 and 17.6 % higher, as compared to groundnut, respectively. However, mustard yield was not influenced due to effect of preceding crops. The yield was also affected due to resource levels and improved levels gave 266.3, 17.5 and 36.8, 49.3 % higher grain, straw yield of wheat and mustard, respectively. The grain and straw yield was 43.7 and 62.3 q/ha of wheat and 3.16 and 11.72 g /ha of mustard, respectively. In case of berseem yield green fodder and dry matter yield obtained under improved levels were higher by 24.4 and 20.4% over farmers level. The yield was 63.8 t GMY and 9.57 t DMY /ha.

In the third year of the experiment during *kharif*, the yield of groundnut dry pod, urd bean grain and maize (cob) obtained under improved levels was higher to the tune of 52.9, 59.8 and 27.5 % over farmers resource levels, respectively. The yield was 21.4 q /ha (groundnut), 16.3 q /ha (*urd* bean) and 81.2 thousand /ha (maize cob), similar trend was also obtained for fresh and dry matter yield of bye-products of different component crops, except groundnut haulms. Higher groundnut haulms yield was due to the spreading type of local variety that have comparatively higher plant height and dry weight/plant. The green and dry haulm yield was 138.5 and 39.6 q /ha under farmers level as compared to 98.0 and 26.5 q /ha in improved levels.

Production, utilization and sustainability of food-forage fuel farming system under irrigated large holding situation

(S.D. Gupta)

Treatments comprised combinations of three cropping systems *viz.* groundnut-wheat, maize (G) + cowpea (F) - Berseem, Sorghum (F) + cowpea (F) - Berseem; three trees associations *viz.*, farm boundary (Pole), Pole (fodder + hedge) and without trees; two fertilizer schedules

(75% of recommended dose and 100% of the recommended dose) and two weed management practices (local farmer's practices and recommended weed management practices) were evaluated.

Tree association did not affect weed intensity, their dry weight, crude protein, grain, straw and dry pod yield, nodule number in legume crops grown in the cropping system.

Recommended weed management practices in wheat crop in caused reduction in weed intensity by 86 per cent and resulted higher production of grain and straw yield by 15.7 and 11.8 per cent over local farmers practice of weed management, respectively (Local farmers practice of weed management, weed intensity 30.5/m^2, grain and straw yield of wheat 28.6 and 52.5 q/ha respectively).

Use of 100 per cent recommended fertilizer dose in wheat and berseem crops grown in cropping systems, increased the production of wheat grain, straw and berseem fodder (green) yield by 16.5, 12.9 and 5.2 per cent over its lower dose of fertilizer (75% recommended fertilizer dose, wheat grain 28.5 straw 53.4 and green fodder yield of berseem 520 q/ha).

In *kharif* season, maximum weed intensity (200/m^2) and its dry weight (13.9 q/ha) were recorded in groundnut crop as compared in sorghum + cowpea (weed intensity 155/m^2, weed dry weight 12.6 q/ ha) and maize + cowpea (weed intensity 154/m^2 and weed dry weight 11.8 q/ha) at 4 weeks stage of crop growth.

Arable food-fodder production systems for medium farmers with different fertility schedules under irrigated conditions

(K.C. Sharma)

The treatments comprised with three cropping systems *viz.*, groundnut - wheat + mustard, maize (cob) - berseem and soybean - wheat + mustard and three fertility schedules *viz.*, 100% recommended through organic sources, 100% through inorganic sources and 50% each through organic and inorganic sources, was laid out in strip plot design.

During *rabi*, in the second year of the experiment, weed populations and dry weight was taken at harvest in wheat + mustard crop and maximum number of weeds (211.5 m^{-2}) and dry weight (80.6 g m^{-2}) was recorded under 100% organic sources as against 50% each organic and inorganic sources (78 and 26.3 g m^{-2}). The yield of wheat and mustard was affected due to preceding crops like groundnut and soybean. The grain yield was obtained 32.8 and 36.7 q /ha of wheat and 1.86 and 1.99 q /ha of mustard after groundnut and soybean, respectively. In case of fertility schedules, wheat and mustard yield recorded under 100% inorganic sources and 50% each organic and inorganic sources was almost equal (42.6 and 41.2 q /ha wheat grain, 66.3 and 61.4 q /ha wheat straw, 2.53 and 1.99 q /ha mustard grain and 12.2 and 12.1 q /ha mustard straw) but the yield was significantly higher over 100% organic sources (20.7, 31. q /ha and 1.26, 7.4 q /

ha grain, straw yield of wheat and mustard respectively). The green fodder and dry matter yield of berseem obtained under all the fertility schedules was almost equal (ranged GMY 61.2 to 62.8 t /ha and DMY 7.34 to 7.54 t /ha).

Recommended weed management practices in *kharif* crops caused reduction in weed intensity and its dry weight by 40 and 56.9 per cent at 4 weeks crop stage respectively and brought out increase in forage, crude protein, maize grain and groundnut pods by 4.3, 0.62, 2.0 and 2.3 q/ha respectively over local farmers practice of weed management (Local farmers weed management, dry forage 34.6 with c.p. 3.84, maize grain 11.7 and groundnut pod yield 13.3 q/ha).

Use of 100% recommended fertilizer doses did not affect weed intensity and its dry weight, but produced additional forage, crude protein, maize grain and groundnut pod yield by 1.3, 0.38, 0.8 and 1.4 q/ha respectively over its lower dose of fertilizer (75% recommended fertilizer dose, dry forage 36.1, C.P. 3.96, maize grain 12.3 and groundnut pod yield 13.8 q/ha).

Among the leguminous crop grown under study, the maximum nodules (104/plant) were recorded in groundnut. However, cowpea in maize + cowpea system showed 17 per cent higher nos. of nodules as compared to cowpea in sorghum + cowpea (Nodules No. 23.4/plant) system.

Recommended weed management practices and use of 100 per cent recommended fertilizer dose increased number of nodule in leguminous crop by 16.6 and 6 per cent over local practice of weed management and 75% recommended fertilizer dose respectively.

Among the cropping systems, sorghum + cowpea - Berseem and Maize + cowpea - Berseem were found equally potential to produce berseem equivalent yield (74 q/ ha). However, these systems were found superior than groundnut - wheat cropping system and produced 20% higher berseem equivalent yield.

Comparative performance of indigenous and improved technologies in different cropping systems under dryland conditions

(K.P. Niranjan, R.L. Arya, A. Singh and J.B. Singh)

Three cropping systems involving (i) Sorghum (CSH 5) + pigeonpea (Bahar) + *Urd* (T 9), (ii) *Urd* + *Til* (T 12) and (iii) fallow - lentil (K-75) and two resources levels (farmers and improved resource) were evaluated. In local practice, traditional practices were adopted.

Improved package of practices increased grain and straw yield of all component crops of the systems as compared to local practices. No yield of sorghum (grain) was obtained due to early withdrawal of monsoon and lack of moisture in soil. Sorghum - pigeonpea + *urd* with improved package of practices yielding 46.5 q/ha of sorghum stover, 91 kg/ha of pigeonpea grain, 1.9 q/ha of straw, 12.9 of stick and 1.9 q/ha grain, 11.2 q/ha straw of *urd*

respectively. *Urd* + *til* intercropping yielded 135 kg/ha of urd grain 10.4 q/ha urd straw and 21 kg/ha of til and 19.7 q/ha stick under improved practices. The lentil crop envisaged during *rabi* in fallow - lentil sequence could not be sown due to lack of moisture.

Maximum gross return of Rs. 8456.00 was obtained in sorghum + pigeonpea + urd cropping system with improved resource levels. Minimum gross return of Rs. 3426.00 was obtained in *urd* + *til* intercropping system with traditional resource levels.

The analysis of long range forecast of south-west monsoon rainfall at micro level indicated that the forecast reliability at Jhansi for all India deficit forecast is 78%. Therefore, one can anticipate that the all India deficit forecast is likely to hold true, and Jhansi region can expect deficit rainfall whenever the forecast for the whole country is deficit. Further, the reliability of normal forecast is less than 70%. This implies that normal rain forecast on all India basis may be shaky in one out of three years for Jhansi region. Therefore, based on the IMD forecast, advance strategic planning for different cropping system can be suggested to farmers under dryland environment.

Thus, sorghum + pigeonpea + *urd* intercropping system proved most efficient and productive intercropping system with improved package of practices under dryland conditions of Bundelkhand region.

Efficient conservation and utilization of soil moisture through resource conservation under dryland conditions

(A. Singh, R.L. Arya, K.P. Niranjan and J.B. Singh)

The treatments consisted of three cropping systems *viz*; C_1 sorghum (CSH 5) + red gram (Bahar) + black gram (T-9) in additive series 2:1:2, C_2 maize (African tall) + cowpea (EC 4216) K to additive series 1:1 - gram (Radhey) + linseed (Neelam) 8:4) and C_3 cowpea _ wheat (Raj 1555) + gram (8:4) along with three moisture conservation/tillage practices for cropping system C_1 (a) Farmer's practice harvesting of sorghum stover as per daily need, (b) harvesting of sorghum stover for silage making and (c) harvesting of sorghum stover for mulching under cropping system C_2 and C_3 after *kharif* crops. The moisture conservation/tillage practices for *rabi* crops were (a) farmer's practice of ploughing by country plough followed by *bakkhar*, (b) ploughing by rotavator followed by planking + mulching with sorghum stover.

Cropping system of sorghum + red gram + black gram (2:1:2) produced sorghum stover (110.61 q/ha), grain (6.38 q/ha) and straw (31.77 q/ha) yield of black gram, grain (1.89 q/ha), straw (2.19 q/ha) and stick (8.01 q/ha) yield of red gram. Maize + cowpea (1:1) intercropping gave highest green fodder (190.02 q/ha) + 98.52 q/ha) and dry matter (57.00 + 19.70 q/ha) yield compared to cowpea (sole) producing 226.8 q/ha green fodder and 45.37 q/ha dry matter yield.

The treatment of sorghum stover harvesting for cropping system (C_1) recorded higher sorghum stover (105.95 q/ha) yield in the treatment of harvesting sorghum stover for silage making.

Significantly higher cowpea green fodder equivalent yield was obtained in sorghum + *arhar* + *urd* (633.58 q/ha) as compared to cowpea (sole) (326.59 q/ha). It was also observed that maize + cowpea gave significantly higher green fodder equivalent (387.34 q/ha) yield over cowpea (sole) cropping system . Among the moisture conservation practices, significantly higher green fodder equivalent yield was noticed in harvesting of sorghum stover for mulching (685.93 q/ha) as compared to farmers practice of harvesting sorghum stover as per daily need (326.59 q/ha). Among the tillage techniques for cropping system C2 and C3, produced higher equivalent yield (368.07 q/ha) in ploughing by rotavator followed by planking + mulching followed by 366.96 q/ha in ploughing by rotavator followed by planking and 355.86 q/ha in ploughing by country plough followed by *bakkhar*.

Information on the periods during which dry weather conditions are likely to prevail could avoid severe moisture stress through appropriate management practices. The detailed analysis revealed that in Jhansi region, the probability of getting rainfall less than 20 mm/week for two consecutive week is less than 10 per cent, once the rainy season sets in, mid season drought are likely to occur during the 33-35th meteorological week i.e. during the mid of August, which can significantly influence the crop production under dryland condition, with a probability of 10-20 per cent due to break in South-West monsoon conditions. Besides that the probability (> 50%) of dry spell increases from Sept. 17 onwards. The potential evapotranspiration was 1412 mm during the 1995.

Production potentiality and sustainability of food-fodder alley cropping system under dryland conditions

(R.L. Arya, K.P. Niranjan, A. Singh and J.B. Singh)

The treatments comprising with three tree association *viz*; farm boundary plantation (*Dalbergia sissoo*), alley species (*Leucaena leucocephala*) and without trees; three cropping systems *viz*; sorghum + cowpea, sorghum + pigeonpea and sorghum + grass strips in the width ratio of 4:1 ; and three manurial schedules *viz*., 100% inorganic fertilizer (60 kg N + 40 kg P_2O_5/ha), 50% inorganic fertilizer (30 kg N + 20 kg P_2O_5/ha) + 6 t FYM/ha and 50% inorganic fertilizer + 3 t leucaena leaves/ha was laid out.

Significant increase in stover and green fodder (60.24 and 93.26 q/ha) yield of sorghum was obtained in no tree association plot. Sorghum + Pigeonpea intercropping (59.64 q/ha) yield was obtained in sorghum + pigeonpea as compared to sorghum + cowpea intercropping system. The sorghum + grass strips also proved superior for producing higher stover and green fodder (57.24 and 145.46 q/ha) yield of sorghum.

Application of 30 kg N + 20 kg P_2O_5/ha + 3t leucaena leaves/ha produced significantly higher stover (63.81 q/ha) yield of sorghum as compared to 100% recommended dose of inorganic fertilizers.

Significantly higher green fodder (93.26 q/ha) and dry matter (21.22 q/ha) yield was obtained in no tree association plot over farm boundary plantations with *Dalbergia sissoo*. Sorghum - grass strips produced significantly highest green forage (145.46 q/ha) and dry matter (36.37 q/ha) yield compared to sorghum + cowpea (127.4 q/ha) green forage and 25.54 q/ha dry matter yield intercropping system. Application of 30 kg N + 20 kg P_2O_5/ha with 3 t Leucaena leaves/ha produced significantly higher green forage (96.21 q/ha) and dry matter (21.84 q/ha) yield of forage crops as compared to 100% inorganic fertilizers. The growth parameters also supported the grain and stover yield of sorghum and green forage yield of forage crops in the systems.

On equivalent basis, the highest sorghum grain equivalent yield (30.49 q/ha was obtained in no tree association plot followed by alley with *Leucaena leucocephala* and farm boundary plantation with *Dalbergia sissoo*. Significantly highest equivalent yield was obtained in sorghum + grass strip plot (32.28 q/ha) over sorghum + pigeonpea intercropping system. Application of 50% recommended dose of inorganic fertilizer + 3t leucaena leaves/ha was found superior for producing highest sorghum grain equivalent yield (32.21 q/ha) followed by 50% recommended dose of inorganic fertilizers + 6 t FYM/ha (29.97 q/ha) and 100% inorganic fertilizers (26.89 q/ha) plots.

The probabilities of occurrence of two consecutive dry week was calculated using the Markov Chain Model. A week exposed with less than 20 mm rainfall is taken as a dry week, the crop can meet the demand from soil moisture. If the rainfall condition (20 mm/week) prevails for two or more consecutive weeks the resultant is the subjectivity of crop to moisture stress in absence of adequate stored soil moisture. The analysis shows that the standard meteorological weeks during which dry spells of two consecutive weeks are likely to commence with probability of 10 per cent, 20-50 per cent and 50 per cent are 27-32 week, 36-37 week and 38 meteorological week onwards respectively.

Silvipastoral systems of production

(P.S. Pathak and M.M. Roy)

Peak growth in major trees was exhibited by *Leucaena leucocephala* in small (Ht = 458.6 cm; cd = 6.7 cm) and large farmer situation (Ht = 484.6 cm; cd = 6.4 cm). In medium farmer situation peak growth was recorded in *Dalbergia sissoo* (Ht = 197 cm; cd = 2.6 cm) closely followed by *Azadirachta indica* (Ht = 172.2 cm; cd = 2.4 cm).

Average dry matter production in small farmer situation was found to be 8.3 t/ha (guinea grass + TSH + stylo + weed + leucaena hedge + tree pruning). In the medium farmer situation it was found to be 4.1 t/ha (natural grasses + stylo +

weed + leucaena hedge + leucaena sowing + boundary leucaena + tree pruning.

Effect of farm boundary plantation on production of crops and vice versa under irrigated and rainfed farming system

(M.P. Rai)

Growth performance of pole trees (*Dalbergia sissoo*)

Dalbergia sissoo planted as pole tree on farm boundary achieved 3.5 m height and 5.8 cm collar diameter (cd) under irrigated farming system and 1.65 m height and 3.2 cm cd in rainfed farming system after 33 months of its growth period (Table 36). The survival of trees was 98% in previous case and 54% in latter case.

Forage production from hedge of *Leucaena leucocephala*

Monthly harvesting was done at 60 cm height of hedge and from July 95 - March 96. 0.456 t dry per row kilometer forage production was obtained.

Table 36 : Growth performance of pole trees (*Dalbergia sissoo*)

Growth period farming system	Under irrigated farming system			Under rainfed		
	Sur%	Height (m)	CD (cm)	Sur%	Height (m)	CD (cm)
After 27 months	98	2.93	5.5	54	1.54	1.8
After 30 months	98	2.97	5.5	54	1.58	2.1
After 33 months	98	3.50	5.8	54	1.65	3.2

Sur = Survival, CD = Collar diameter

Effect of farm boundary plantation on field crop production

The production of forage and grain yield from field crop as affected by boundary plantation is presented in table 37. The perusal of table indicates that there was reduction in forage production at 1m distance from the boundary plantation. The reduction level was 6.6% in case of

Table 37 : Production of forage and grain yield as affected by boundary plantation (q/ha dry)

Crops	Control (without plantation)	Pole trees	Pole trees + Hedge
Sorghum + Cowpea	53.0	40.5	49.0
Maize + Cowpea	41.5	39.5	39.4
Groundnut	13.8	12.9	12.8
Berseem (green)	500.0	480.0	485.0
Grain yield of Maize	12.5	11.5	11.4
Grain yield of Wheat	29.5	27.5	27.5

cowpea with sorghum and groundnut, 4.8% in case of maize with cowpea and 4% in case of berseem. The grain yield was reduced by 8% in case of maize and 6.8% in case of wheat at 1m distance from farm boundary.

Alley farming on large farm holdings under rainfed conditions

(R.C. Singh and Sudhir Kumar)

A general trend showed that cropping system, sorghum + pigeon pea (C_2) gave better result in terms of green fodder yield in all the three cuttings *viz.*, September 95, December 95 and February 96, whereas in fertilizer management, 50% inorganic fertilizer + 6 t FYM/ha (F_2) showed good results. Among all the cuttings, higher yielded was obtained in the month of September 95. The treatments C_2 and F_2 remained superior to others.

Among cropping system C_3 (sorghum + grass strips) gave maximum survival over the other *viz.* C_1 (sorghum + cowpea) and C_2 (sorghum + pigeon pea). However, in fertilizer management, F_2 (50% inorganic fertilizer + 6 t FYM/ha) showed maximum survival followed by F_3 (50% inorganic fertilizer + 3 t Leucaena leaves/ha) and F_1 (100% inorganic fertilizer i.e. 60 kg N + 40 Kg P_2O_5/ha).

Production, utilization and sustainability of forage farming system under rainfed/irrigated condition- physiological and biochemical components

(L. P. Misra, R. K. Bhatt and Amaresh Chandra)

Silvipastoral system

The *Leucaena, Acacia* and *Dalbergia* and grasses *(C.ciliaris* and *D. annulatum)* and stylo (range legume) were evaluated during the third year of growth in the system. Higher leaf area index, crop growth rate and specific leaf mass were observed in *C. ciliaris* under all tree canopy followed by *D. annulatum* and stylo indicating their relative association with different trees. Although the effect of tree canopies on the under canopy growth was negligible which may be due to low canopy size. Both the grass and stylo maintained the optimum rate of photosynthesis, transpiration and stomatal conductance under all trees.

Panicum maximum and trispecific hybrid were also evaluated with various other MPTS under rainfed condition during the third year of establishment and the results revealed that trispecific yield high specific leaf mass, crop-growth rate and dry matter as compared to *P.maximum.*

Grass - legume association

Comparative studies of three range grasses (Viz. *Cenchrus ciliaris, Chrysopogon fulvus, Dichanthium annulatum*) and three legumes *viz. Stylosanthes hamata* (Stylo), *Macroptelium atropurpureum* (Siratro) and *Cajanus cajan* (Arhar) in grass-legume mixed cropping system under rainfed condition revealed that in third year grasses produced higher biomass than legumes. Among all species *C.ciliaris* produces maximum dry matter yield and leaf area. Stylo and Siratro showed good association

with grasses as compared to *Arhar*. This is evidenced by higher accumulation of Chl b under stress environment with the grasses. However, the higher diffusion resistance for water vapour transfer in grasses indicates their adaption potential under rainfed condition.

The activity of nitrate reductase (NR) and protease was measured this year also. After three years of establishment and growth, grasses have dominated over the legumes as it was evident from the fact that pigeon pea got completely perished this year. The nitrate reductase activity was found maximum in *Cenchrus* in the category of grasses while *Stylosanthes* in the legumes. The activity of protease which indicates the rate of proteins breakdown in the different part of the plants was assayed and it was found that stylo showed least decrease in the activity over the year of establishment and in grasses category *Chrysopogon* showed the same pattern which indicates that they have the potential to grow better even in the adverse conditions.

Total carbohydrate and starch was measured in oven dried samples. The level of starch was found reasonable especially in *Cenchrus* (17.4 mg/100 mg dry sample) and in stylo (4.4 mg/100 mg dry sample) over the other grasses and legumes. This indicated the high dry matter yield and leaf area by these two species over the others.

Physiology of crops under inter cropping system

Rainfed condition : The higher light absorption under sorghum (grain) + cowpea in 50 per cent of recommended inorganic fertilizer + 6 t FYM and 3 t/ha Leucaena leaves yielded higher biomass production, crop growth rate and leaf area. In sorghum (grain) + Pigeonpea + Urd intercropping system, cowpea received 35 per cent, whereas pigeon pea and Urd received 80% and 30% of total PAR. The association potential of cowpea was more than other crops in the inter cropping system.

Irrigated condition : Maize + cowpea (1:1) and sorghum (F) + cowpea (2:2) were evaluated for their growth and other physiological characters under irrigated condition. Cowpea received 55% PAR in maize + cowpea intercropping system whereas 39% under sorghum which caused higher crop growth rate and leaf area production in this crop in the former system than the later system.

Development of feeding strategies of different types of livestock in relation to available feed resources under different farming systems

(V.S. Upadhyay, A.P. Singh, S. Radotra, S.B. Maity, A.K. Mishra and N.P. Singh)

Large farmer

The total 6.0 ha land holding of large farmer was distributed as rainfed crop 2.4 ha; irrigated crop 1.2 ha; pasture 1.2 ha and silvipasture 1.2 ha. Livestock resource under the system were 4 cows, 4 buffaloes, 2 heifers and 6 calves units. Annual DM requirement for livestock was 38.04 tonnes and availability was

only 21.64 tonnes. Total milk production was 7105.0 kg for cows, 6411.0 kg for buffaloes.

Medium farmer

Land holding of medium farmer was 2.76 ha land, distributed into irrigated 0.54 ha, rainfed 1.62 ha and natural pasture 0.6 ha. Livestock resources under this condition were 2 cows, 1 Buffalo, 2 bullocks and 6 goats units. The annual dry matter requirement was 20.96 tonnes but the actual availability was only 11.2 tonnes as there was no sowing in irrigated land due to some unfavorable conditions. Goats average in general maintained on grazing for 6 hrs, *ad lib* dry grass and supplementation of concentrate mixture of green cowpea or *Leucaena leucocephala*. It was found that the reproductive performance of goats could be augmented by salt and mineral mixture supplementation.

Small farmer

The land holding of small farmer was 1.29 ha and distributed in 0.37 ha irrigated, 0.72 ha rainfed and 0.20 ha under agro-silvipasture. Livestock resources were 8 goats, 2 cows and 2 calves. All goats were kidded. Total fodder production from different systems was 147.94 q on fresh basis and 48.58 q on DM basis which was not sufficient to meet the DM requirement (58.36 q) of the available livestock resources. Different resource combination were used maintaining the stock. Basically reared on grazing with supplementation of either concentrate or cowpea fodder or berseem fodder or foliage of *Leucaena leucocephala*.

COORDINATED AND ADHOC EXTERNAL RESEARCH PROJECTS

AICRP ON FORAGE CROPS

(Coordinating Unit, IGFRI, Jhansi)

Varietal Development

On the basis of multilocational testing, the crop varieties, which have shown promise for further testing and subsequent identification and release, are listed in table 38.

During the year, a number of varieties have been released and notified by the Central Seed Sub Committee on crop standard, notification and release of varieties. In case of sorghum, a multi-cut (3-4 cuts) hybrid Punjab Sudex Chari-1 (LX-250) has been released for Punjab State. A single cut variety of sorghum, Haryana Chari-308 (HC-308) variety Hara Sona (855 F), resistant to various leaf diseases and having field tolerance to major insect and pests and another multicut 94-5 sorghum variety, fairly resistant to foliar disease have been centrally released and notified. A variety of cluster bean, Bundel guar-2 (IGFRI-2395-2), resistant to *Xanthomonas* and *Alternaria* diseases, has been released and notified for entire guar growing tract. Sheetal (HPNN-1) variety of Ghobi sarson has been centrally notified for H.P. Lucerne variety, RL-88, a very good perennial material (5-6 years), highly resistant to stem rot and having good seed potential (350 kg/ha), has been centrally released and notified. Fenu greek, ML-150 has been released in the state of Punjab as fodder variety and centrally notified.

Production technology

Application of *Azotobacter* to Dinanath grass resulted in increased forage yield by 10%, over control and contributed about 25 kg N equivalent per ha at Jabalpur. Seed inoculation is much more effective than soil application. At Bhubaneswar, application of *Azotobacter* to maize crop resulted in 27 per cent of dry forage yield over *Azospirillum* application. At Coimbatore, highest forage yield of bajra-napier hybrid was obtained with Azospirillum + phosphobacterium than any of them alone. At Vellayani, highest forage yield of *Stylosanthes scabra* was noted with VAM + Vermi-compost.

At Urlikanchan, it was observed that 75% of recommended level of NPK fertilization along with 10 t FYM/ha gave highest monetary return to a crop rotation of sorghum-berseem-pearl millet. Similar level of fertilization also gave highest yield and return at Anand with crop rotation of bajra-lucerne-cowpea.

In the major crop of the region like maize at Bhubaneswar, cowpea intercropping was found to be best for yield and monetary return when grown in 2:2 ratio. At Rahuri, sowing of sorghum at 45 cm and a row of soybean in between gave

Table 38 : Varieties showing promise for further testing for identification and release

Crop	Variety	Suitable area for cultivation
Cowpea	UPC-93-1	North-East
	UPC-942, CL-341	Central, South
	UPC-93-4	North-West
Guar	GL-566	Entire guar growing tract
Maize *(kharif)*	FML-23	Central, North-West
Maize *(rabi)*	APM-22, FML-15	Entire growing tract
Guinea grass	PGG-489	Central
	PGG-552	North-East
	PGG-297	South, Entire country
Anjan grass	IGFRI-3133	Entire arid and semi
	CAZRI-358	arid
Bajra	FMH-3, DRSB-2, (Single cut) DRSB-1	Entire growing area
Bajra	FMH-3, FMH-2, (Multi cut) HTGP-K-1993	Entire growing area
Rice bean	BC-15, BC-18	Entire growing area
Berseem	JHB-92-2	North East
	JB-90-2-56	Central
	JHB-93-4	Entire growing area
Lucerne (Annual)	Poona-1	Entire growing area
Shaftal SH-87	SH-local, SH-121,	Entire growing area
Oat	OS-237	North-West
	OS-196	South
	OS-240	Entire growing area

highest yield advantage. However at Kanke, cowpea intercropping depressed the yield of fodder maize and also total herbage.

Weedicide like atrataf w.p. @ 1.5 kg/ha was found quite effective in controlling weeds in maize at Kalyani. This together with one hand weeding at 42 days is found to be most effective and gave highest herbage yield. Atrazine @ 1.0 kg/ha was found to be the best weedicide for sorghum at Bhubaneswar and Jabalpur.

Highest green forage yield of maize was obtained with 50% NPK + 20 t piglet per ha and gave a yield increase by 21 per cent over 100% per cent recommended level of fertilizer application. Berseem-groundnut is found to be most remunerative crop sequence at Rahuri. At Vellayani, gamba grass was found to be much higher yielder (20% more) than guinea grass. The seed crop of rice bean is found to be much responsive to

phosphorus. Highest seed yield was obtained at 60 kg P_2O_5/ha. Both jowar and maize responded to K and lime application. Significant yield increases were noted with K at 30 kg/ha and 1.5 t/ha of lime in low pH soils (pH 5.5).

In case of lucerne, 15 kg seed rate of variety Anand-3 gave highest monetary return of Rs. 89,300.00 at Rahuri. Seed yield of shaftal (2.97 q/ha) was possible to be produced at Kalyani in an uncut crop an increase by 296 and 70 per cent over two cuts and one cut crops respectively. Early sowing crop (last week of October) than a late sown crop (last week of November) gave higher yield. Maximum return of Rs. 30,000.00 was obtained from a dual purpose maize crop (fodder-cum-green cob) at Jhansi.

1.4 : Effect of organic manures (FYM) and fertilizers on forages

The data on two crop sequences (Sorghum-berseem and sorghum-oat) at four fertility levels viz., 100 per cent recommended dose of NPK and 75 per cent recommended dose of NPK plus 10 ton FYM in *kharif*, *rabi*, and *kharif* and *rabi* both revealed that sorghum-berseem crop sequence produced significantly higher green (1360.8 q/ha) and dry matter (255.5 q/ha) yields than sorghum-oat sequence. In case of fertilizer application, the 75 per cent recommended dose of NPK plus 10 ton FYM/ha in *kharif* and *rabi* both produced higher green and dry matter yield than 100% application of recommended dose of NPK.

1.5 Performance of rabi maize with other forages

Rabi maize raised for fodder, cobs and fodder and grain was compared with other popular *rabi* fodder crops like lucerne, berseem and oat. The data revealed that significantly higher return to the tune of Rs. 30,040/- per ha was realized with maize crop grown for dual purpose i.e. green cobs and fodder. The berseem crop ranked second after maize (dual purpose). The minimum monetary return of Rs. 9,630.00 per ha was obtained with oat crop followed by maize (grain).

1.6 Response of phosphorus to promising varieties of lucerne

The experiment consisting four promising varieties of lucerne (RLS-88, LH-84, RLS 87-1 and LLC-3) and four levels of phosphorus (0, 40, 80 and 120 kg P_2O_5/ha) was carried out at Jhansi Centre. Varietal response was found non-significant in case of green and dry matter yield. However, cv. RLS 87-1 gave more green and dry matter yields than others. In case of phosphorus levels, the forage yield increases significantly with the increasing levels of phosphorus up to 80 kg P_2O_5/ha. The increase in green and dry matter yield was recorded to the tune of 61 and 53.6 per cent respectively over control.

1.7 Response of phosphorus to promising varieties of Lablab beans under rainfed condition

At Jhansi JLP-6 was tested against check variety JLP-4 at two levels of sulphur (0 and 40 kg S/ha) and three levels of

phosphorus viz., 0, 40 and 80 kg P_2O_5/ha. JLP-6 produced 28 per cent more green and dry matter yield over check (JLP-4). The effect of phosphorus and sulphur was obvious on the forage yield of Lablab beans. Significantly higher green and dry matter yield was recorded with the application of 80 kg P_2O_5 and 40 kg S/ha. The interaction between varieties and sulphur was found significant. The entry JLP-6 produced significantly higher dry matter yield to the extent of 64 q/ha at 40 kg S/ha.

AICRP FOR DRYLAND AGRICULTURE

Frontline demonstrations on oilseed based cropping systems under dryland conditions

(R.L. Arya, P.S. Tomer and Mahabir Singh)

Five frontline demonstrations on oilseed based cropping systems were conducted at the farmer's field in an area of 0.4 ha.

1. Mustard (pure) on conserved moisture.

2. Linseed + mustard (9:2) intercropping on conserved moisture.

Sole cropping of mustard with improved package of practices in different demonstrations at farmer's field produced higher grain yield of mustard with sole cropping of mustard. Using improved package of practices it was 100 per cent over sole cropping of mustard with traditional package of practices.

As regards intercropping of mustard with linseed, using improved package of practices vs sole cropping of linseed with traditional package of practices, the intercropping system gave more linseed yield in addition to the yield of mustard (250-325 kg/ha).

Further, it was noted that linseed grain equivalent yield from the intercropping of mustard with linseed using improved package of practices was much higher over that of sole cropping of linseed using traditional package of practices. The increase in linseed grain equivalent yield with former over the later was 53.4 per cent.

Thus, the intercropping systems not only showed the feasibility of obtaining pulse and oilseed concurrently, but also proved most productive system on conserved soil moisture under dryland conditions of Bundelkhand, where mustard or linseed is traditionally grown as sole crop.

Network Collaborative Project on Crop based livestock production system

(V.C. Pachauri, N.C. Verma, R.B. Varshney, B.K. Trivedi, A.B. Mojumdar, R.B. Yadav, Sandeep Saran and Mukesh Kumar)

Water conservation

Water run off and Soil losses were estimated in different pasture utilization systems viz., rotational grazing, deferred rotational grazing, continuous grazing, cut and carry system and bare plots

(Table 39). No grazing was allowed during rainy days (from 1st July to 31st August, 1995). Highest rainfall (738 cum/ha) on 3-8-95 and minimum run off (21.01 cum/ha) was recorded in rotational grazing system on 3rd August, 1995. The lowest rainfall (31.0 cum/ha) was recorded on 5th August, 1995 and minimum run off was found in different rotational grazing system (i.e. 10.5 cum/ha).

Soil fertility studies

Representative surface soil (0-15 cm) samples were collected from each plot. Samples were analysed for pH, organic carbon and available nutrients *viz.*, nitrogen, phosphorus and potassium.

Though soil fertility status varied among different plots, it was not significantly affected by the pasture utilisation systems at this stage (one year of grazing) (Table 40).

The loss of total soluble salts varied from 7.81 kg/ha under cut and carry system to 28.25 kg/ha under bare plot. Similarly, maximum dissolved nitrogen and potassium were found under bare land (Table 41). The concentration of dissolved phosphorus in run off water samples was in traces and hence its loss could not be quantified.

Pasture improvement studies

Data on the establishment of four range legumes namely *Atylosia scarabaeoides*, *Clitoria ternatea*, *Macroptelium atropurpureum*, *Stylosanthes hamata* introduced in 1992 indicated that *A. scarabaeoides* and *S. hamata* established in all the four systems and the earlier species showed higher establishment except in continuous systems while in case of later species establishment percentage decreased over initial value in all the systems. *M. atropurpureum* could

Table 39 : Rainfall, Run off and Soil loss

System of grazing	Run off cum/ha	Soil loss kg/ha	Run off Coefficient (%)
Rotational grazing	125.11	3.64	3.36
Deferred-rotational grazing	147.01	5.84	3.94
Continuous grazing	155.92	5.01	4.18
Cut & carry system	140.55	3.60	3.77
Bare plot	457.62	23.80	12.29
Rainy days	-	56 days	
Rainy days produced with run off	-	16 days	
Total run off	-	3727 cum/ha.	

Table 40 : Soil fertility status under differnt pasture utilisation systems

Systems	pH	O.C. (%)	Available Nutrients (Kg/ha)		
			N	P	K_2O
Rotational grazing	6.34	0.49	187.8	7.8	160.4
Deferred Rotational grazing	6.33	0.50	186.7	7.3	158.1
Continuous grazing	6.30	0.49	187.9	7.0	158.5
Cut & Carry system	6.31	0.49	180.6	7.3	158.7
Bare plots	6.20	0.30	120.0	4.5	110.0

Table 41 : Nutrient loss under different pasture utilization systems

Systems	Nutrients (kg/ha)			
	Total soluble salts	N	P	K
Rotational grazing	8.08	0.320	*	0.642
Deferred Rotational grazing	8.39	0.330	*	0.572
Continuous grazing	8.55	0.328	*	0.636
Cut & Carry system	7.81	0.293	*	0.600
Bare plot	28.25	0.973	*	2.365

* In traces.

establish only in continuous system while *C. ternatea* did not establish in any of the systems.

Botanical composition

Phytosociological studies listed 63 herbaceous species from experimental plots out of which, there were 8 perennial, 15 annual grasses,17 legumes and 23 forbs. On the basis of Importance Value Index (IVI) the order of these species groups were grasses-legume-forbs in all these grazing systems. Highest species diversity (31 species) was recorded in continuous grazing and lowest (24 species) in rotational grazing. *Heteropogon contortus* and *Sehima nervosum* were found in all the grazing systems.

S. nervsoum was found dominant in three systems viz., rotational, deferred rotational and cut & carry with 71.9, 71.3 and 83.3 IVI, respectively while in first two systems *H. contoirtus* was co-dominant with 47.2 and 43.3 IVI, respectively and in third system i.e. cut & carry *Dichanthium annulatum* was co-dominant with 31.4 IVI. In continuous grazing paddocks *H. contortus* was dominant and *S. nervosum* co-dominant with 51.1 and 40.1 IVI, respectively.

Plant biomass (Herbage Production)

The average herbage production of the experiment ranged from 3315 ± 637.6 to 4180.6 ± 445.7 kg/ha, respectively in cut & carry and deferred rotational grazing systems. The rest two systems i.e. rotational and continuous produced respectively 172 and 208.2 kg more herbage than cut and carry system. About 90 per cent of total biomass was contributed by grass component of the community while legume could add only 6-7 per cent of the total. Maximum litter production (129.0 g/m^2) was recorded in deferred rotational system.

Forage evaluation and livestock production studies

In each system, 9 sheep (corriedale cross), 9 goats (Barbari Breed) and 4 crossbred heifers were put for grazing from 1st Sept., 1995. One group was kept for stall feeding under cut and carry system of management.

Forage samples taken from each plot. The CP content was 5.3, 6.0, 5.5 and 5.4 per cent in herbage of rotational, deferred rotational continuous and cut and carry systems, respectively. Similarly, NDF content was 77.5, 76.7, 74.7 and 78.4 % and ADF content was 52.4, 50.9, 52.2 and 55.9 per cent, respectively. IVLMD values were found to be 40.4, 38.9, 40.3 and 38.0 per cent in rotational, deferred-rotational, continuous and cut and carry systems, respectively.

Wool clipping of sheep was done during the second week of October, 1995 and it was observed that total wool yield of 7.830 kg (0.870 kg/sheep) in rotational grazing, 7.590 kg (0.843 kg/sheep) in deferred rotational grazing, 10.320 kg (1.147 kg/sheep) in continuous grazing and 6.470 kg (0.719 kg/sheep) in cut and carry system of grazing management.

Livestock production

In goats, the kidding percentage was found to be 100% in continuous grazing system whereas it was 67% in rotational grazing, 78% in deferred-rotational grazing and 22% only in cut and carry system of feeding management. Out of kids born 50% were twins in continuous grazing, 28.5% in rotational grazing and 44% in deferred rotational grazing system. In cut and carry system three goats having twins aborted.

In sheep, the lambing percentage was found to be 100% in cut and carry system whereas it was 89% in rotational grazing, 56% in deferred rotational grazing and 78% in continuous grazing system. The overall percentage of male lambs born was more as compared to female lambs.

In cattle, under rotational and deferred rotational grazing, two heifers in each system showed cestrus and were served by natural service (Jersey Bull) at the age of 24 months. Whereas under continuous grazing and cut and carry system only one heifer in each system was served by Jersey bull at the age of 24 months.

Blood profiles of animals under different grazing systems

Blood samples from crossbred heifers put under four grazing systems i.e. rotational, deferred rotational, continuous grazing and cut and carry system have been drawn seasonally and analysed for serum protein, albumin, globulin and cratine kinase activity (Table 42).

The results indicate on comparatively better growth of animals in deferred rotational and rotational system of grazing.

AP CESS FUND PROJECT

Photosynthesis and shade tolerance in tropical range grasses and legumes

(L. P. Misra and R.K. Bhatt)

Twelve grass species and one range legume (Siratro) were evaluated for this morpho-

Table 42 : Blood metabolities of heifers (% change)

Grazing system	Total protein	Albumin	Globulin	Creatine kinase activity
Rotational	-15.7	-11.6	+ 5	+16
Deferred-Rotational	+ 3.35	- 4	+12	+15
Continuous	- 6.1	-23	+10	-10
Cut & Carry	-14.5	-23	- 5	-18.5

physiological behaviour and physiological functioning under open and shade environment (35-40%). In general the plant height, fresh weight and dry matter yield increased in almost all species under shade environment except in *B. brizantha* and *Macroptelium atropurpureum* (Siratro). Overall the maximum dry matter accumulation and LAI were observed in *C. setigerus* followed by *B. decumbense, D. annulatum* while it was at par in *P. maximum* (Var. PGG) and trispecific hybrid under shade condition. All plant species accumulated higher chl. b under shade environment.

High shade tolerance index was observed in trispecific hybrid, *P. antidotale, P. maximum* and *C. setigerus*. The rate of photosynthesis, transpiration and stomatal conductance reduced to half under shade environment. However, the carboxylation efficiency (PN/CINT) was estimated in *P. antidotale, B. mutica, B. decumbense, Panicum maximum* and trispecific hybrid under shade condition as compared to other species tested. In general all the morphophysiological parameters reduced in *Macroptelium atropurpureum* (a range legume species) under shade (35-40%) indicating its lower adaptability under high shading degree.

Studies on the role of VAM fungi in management of root-knot and stunt nematodes on berseem, Lucerne and cowpea

(R.K. Jain, N. Hasan, R.B. Bhaskar)

Survey and mycorrhizal infection status of some weeds

At C.R. Farm, predominant genera of VAM identified belongs to *Glomus* and *Gigaspora*. Four species of *Glomus viz., G.fasciculatum, G.aggregatim, G. interadics, G. mosseae* and an unidentified species of *Gigaspora* were generally encountered. However, *G. fasciculatum* seems to be the predominant species.

All weed species were mycorrhizal, however, a wide range of variation with regard to per cent root colonisation and number of spores of VAM fungi were recorded. *Triathema portulacastum* was observed to be heavily infested with VAM fungi showing 90% root colonisation along with abundant mycelium and arbuscules without vesicles.

Mycorrhizal dependency of *Medicago* and berseem

Both inter and intraspecific variation with regard to Relative Mycorrhizal Dependency (RMD) and per cent mycorrhizal root colonisation (Fig.). All the *Medicago* species except *M. arbica* 3792 responded to mycorrhizal inoculations. *M. scutellata* 8042 and *M. littoralis* 130 were highly responsive to mycorrhizal inoculations showing RMD values 153.06 and 138.99 respectively.

Similarly the berseem variety/lines also exhibited considerable variations with regards to RMD values and per cent root colonization. Wardan was found to be most responsive to mycorrhizal inoculations.

Nematode penetration and development studies as influenced by VAM fungi on cowpea, berseem and lucerne

Mycorrhizal inoculations considerably reduced the initial nematode penetration (20-24%) in all the three forage crops studies. However, once the nematode penetrated their further development was not initiated by the presence of mycorrhizal fungus. At the end of 30 days of observations matured females with viable eggs were observed in both mycorrhizal as well as non-mycorrhizal plants roots.

Nematode - VAM interaction studies on cowpea, berseem and lucerne

Prior establishment of VAM fungi (*G.fasciculatum)* by a week or two tended to mitigate the adverse effect of the nematode *M. incognita* on the plant growth of cowpea, berseem and lucerne.

Prior inoculation of *G. fasciculatum* by two weeks can potentially mitigate the adverse effect of root-knot nematodes in cowpea, berseem and lucerne.

As far as the interactive effects of *T. vulgaris* and *G. fasciculatum* on berseem and lucerne is concerned, the establishment of fungus reduced the nematode reproduction irrespective of the time of establishment of either of the organism. However, the prior establishment of the fungus by 15 days was highly significant in reducing the nematode reproduction (50%). Therefore, *G. fasciculatum* may potentially be utilised in management of the *T. vulgaris* in berseem and lucerne.

Integrated nematode management (INM) in cowpea

A field experiment with 4 main treatments (multching) and sub-treatments (chemicals and neem products) each and their combinations were laid down to manage the nematodes infecting cowpea (Fig. 11).

All the treatments significantly increased the green and dry fodder yield and reduced the nematode population over the control. However, highest green and dry fodder yield was recorded where black polythene was combine with neem cake whereas, highest nematode population reduction was recorded in the treatments consisting of black polythene with carbofuran. In addition none of the treatments exhibited any kind of adverse effect on VAM spores in the soil.

As far as the observations on the soil temperature are concerned mulching with white polythene significantly increased the soil temperature as compared to other mulchings (Fig. 11).

Response to different sources and levels of Phosphorus

DAP at the rate of 80 kg/ha with VAM yielded maximum fodder yield (26.5 g/pot) followed by DAP 90 alone. There was no significant difference at low levels of phosphorus (20 kg). The plant height was maximum with DAP 80 plus VAM. There was no interactive effect between the VAM and source of P as well as VAM

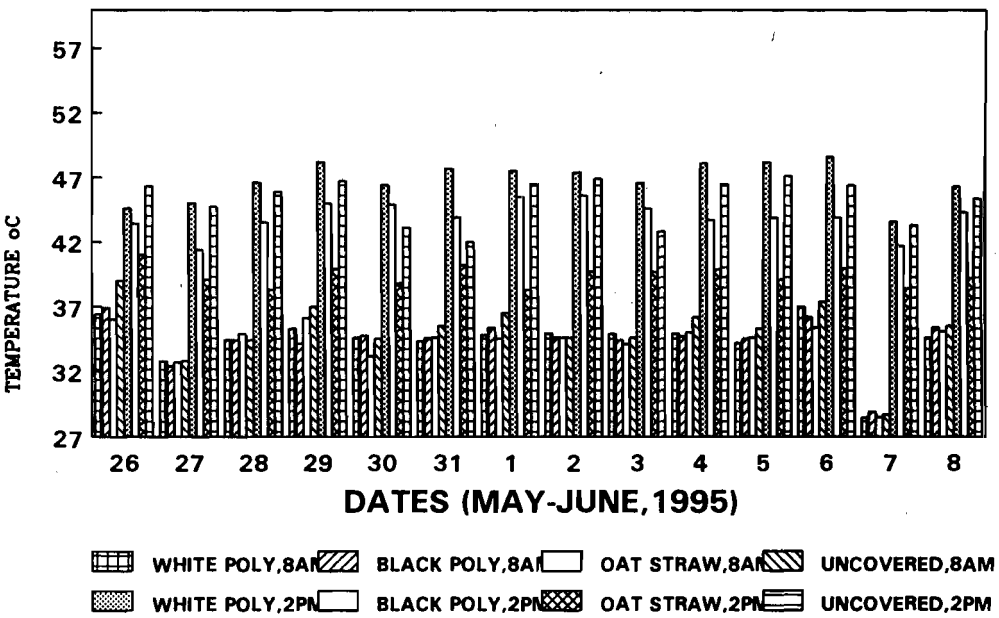


Fig. 11 : Effect of mulch on soil temperature

plus dosses of P. The per cent root colonisation was not affected by the source and levels of Phosphorus.

Response to different levels of Phosphorus

There was progressive increase in the plant growth with the increasing levels of phosphorus. Presence of mycorrhizal fungi further enhanced the plant growth. There was significant increase in green fodder weight over the control in all the treatments. Maximum increase was recorded at P 80 plus VAM followed by P 40 plus VAM. However, there was no effect of levels of P in per cent root colonisation.

REGIONAL RESEARCH STATION, AVIKANAGAR

The Western Regional Research Station (IGFRI) has peculiar environment such as poor soil fertility and productivity, scare and erratic rains, sandy soil having low water holding capacity and higher infiltration rate, higher soil erosion, high temperature during summer, low relative humidity, high wind velocity, high evaporation rate and lack of irrigation facilities. Research at this centre is of vital importance and cater needs of semi-arid regions of Rajasthan, Gujarat and Haryana having similar nature of climate,

WRRS-3 : THE ECONOMICS OF CULTIVATED FODDERS, RANGE GRASSES AND LEGUMES

(Mallaya)

3.1 Economics of seed production

Total cost of production /ha for *Cenchrus setigerus*, dolichus and guar were Rs. 21,85, Rs. 2952.00, Rs. 2396.00 respectively. The input-output ratio of *C. setigerus* seeds and grasses, dolichus, and guar seeds were 1:1.72, 1:1.73, 1:1.08, 1:1.20, respectively.

3.2 The study on economics of *Clitoria* forage production

In Co-ordinated varietal trial at WRRS, IGFRI-D1-1 and CAZRI-1441 were superior (Table 42). The data on various operational costs have been recorded for further study.

Table 43 : Performance of Clitoria varieties in Co-ordinated Trial at WRRS

Variety	Fresh fodder yield (Q/ha) at flowering stage
1. IGFRI-1531-1	51.6
2. CAZRI-468	56.7
3. IGFRI-171-1	70.8
4. CAZRI-752	69.2
5. IGFRI-94-1	50.0
6. CAZRI-466	50.0
7. IGFRI-7-3	50.8
8. CAZRI-1441	70.8
9. CAZRI-23-1	60.0
10. CAZRI-1428	45.1
11. CAZRI-1433	48.0

Among the 11 varieties tested, var. IGFRI-171-1 & CAZRI-1441 proved superior performers.

3.3 The study on economics of effect of different spacing on the yield of grasses under *Acacia nilotica*

Two grasses *Cenchrus ciliaris* and *Panicum antidotale* with six spacings were tested under *Acacia nilotica*. About 40% *A. nilotica* plants died in the summer. *C. ciliaris* gave higher yield over *Panicum antidotale*. The better yield, higher collar diameter and height were recorded under wider spacing as compared to narrow spacing.

3.4 The economic study on effect of trees and vice-versa

Four tee species namely, *Ailanthus exelsa*, *Acacia nilotica*, *Prosopis cineraria Albizia lebbek* and three grasses namely *Panicum antidotale*, *Cenchrus ciliaris*, *C. setigerus* were used for determining most suitable tree under which maximum grass yield may be obtained. There were sixteen treatments combinations including control. Mortality of *Ailanthus excelsa* and *Acacia nilotica* were higher due to white ants and hot dried summer. The *C. setigerus* produced maximum biomass. The maximum height and collar diameter were recorded under *Albizia lebbek*. The minimum collar diameter and height were recorded under *Prosopis cineraria* due to slow growth.

REGIONAL RESEARCH STATION, DHARWAD, KARNATAKA

The Regional Station of Indian Grassland and Fodder Research Institute, Jhansi, was set up at Dharwad during May, 1987. The centre is engaged in research on improvement and management of grasses, grasslands and cultivated fodder crops of peninsular India.

Tegur, Dharwad is situated at latitude 15°27' and longitude 75°05'. Height above mean sea level is 678 meters. The average annual temperature is more or less similar over greater part of the regions. In March/April highest mean annual daily maximum temperature of about 37°C occurs. During November, December and January the temperature is fairly low and lowest daily minimum temperature of about 11°C is recorded during December. The rainfall in the region is summer dominant and during 1995, the farm area received about 797.2 mm rainfall from January to November.

SRS 1.6 Genecology of range grasses *Dichanthium annulatum*, *Dichanthium caricosum* and *Sehima nervosum*

(P.K. Jayan and D.H. Sukanya)

During second year, four populations each in *Dichanthium annulatum, D. caricosum* and *Sehima nervosum* grown in natural grassland were studied in for the intraspecific variations. The populations were heterogeneous and the segregated populations of the grass species grown under natural conditions were studied for various morphological attributes and forage yield. A wide range of variability was observed.

In *Dichanthium annulatum*, growth habit varied from erect bunchy to procumbent growth form and flowering time from early to late. Maximum height of plants varied from 118.2 to 49.2 cm. The number of tillers per plant ranged from 76 to 187 and internodel length was recorded maximum 15.3 cm and lowest 9.3 cm. Leaf/stem ratio varied from 0.40 to 0.58. Herbage yield (green) was recorded highest in population IV (390.0 q/ha) followed by population III (323.3 q/ha) and lowest in population II (70.8 q/ha). The persistency of plants after second year of establishment was cent percent for populations I, III and IV while in population II 7.5 per cent plants degenerated/dead.

Among the four populations in *Dichanthium caricosum* studied, plant height varied from 133.3 to 202.2 cm. Number of tillers per plant ranged from 144 to 164.0. Internode length was recorded maximum as 18.3 cm and as 10.3 cm. Leaf/stem ratio ranged from 0.45 to 0.61. Herbage yield (green) was recorded highest in population II (522.5 q/ha) and same was lowest in population III (417.5 q/ha). The percentage mortality in different populations ranged from 12.5 - 20.0%.

In the provenance trial, variability studies in four populations of *Sehima nervosum* continued for the 2nd year. Height of plant varied from 120.5 to 161.0 cm. Number of tillers per plant varied from 193 to 251. Leaf/stem ratio varied from 0.60 to 0.85. Green forage yield varied from 291.6 q/ha (population I) to 245.6 q/ha (population - III).

High incidence of leaf blight was recorded in populations II, III and IV causing up to 30 per cent mortality, while in population I, the incidence of disease was minimal (12.5% mortality).

SRS-3 : VARIETAL EVALUATION OF CULTIVATED FODDER CROPS UNDER ON-STATION AND CO-ORDINATED TRIALS

KBTC - 1 Initial varietal trial on fodder cowpea

(D.H. Sukanya and P.K. Jayan)

Out of nine entries, the entries IFC - 9502 and UPC - 952 were found significantly superior with green fodder yield potential of 33.3 t/ha and 31.7 t/ha respectively as compared to best check UPC-5286 (27.2 t/ha).

KBTC - 2 Advanced varietal trial on fodder Cowpea

(D.H. Sukanya and P.K. Jayan)

Out of seven entries, UPC - 93 - 1 and IFC - 9402 were found significantly superior for green fodder yield (31.6 t/ha and 31.7 t/ha, respectively).

KBTB - 11 Varietal evaluation in fodder bajra

(D.H. Sukanya and P.K. Jayan)

Fourteen entries of fodder Bajra were evaluated with UUJ - IV m as the check. The entry DRSB - 2 recorded significantly superior green fodder yield of 39.2 t/ha, followed by HT - Garapool (38.1 t/ha), DRSB - 3 (36.7 t/ha) and DRSB - 4 (34.5 t/ha).

RBTD 3 and 4 Evaluation trials on multicut oats

(D.H. Sukanya and P.K. Jayan)

Out of 16 entries tested in initial evaluation trial, the entries OS - 242, JHO - 94 - 3 and JHO - 996 recorded significantly superior performance with green fodder yielding potential of 21.8, 21.7 and 20.8 t/ha respectively, as compared to best Check Kent (17.08 t/ha).

In advanced varietal trial, out of 7 entries, the entries UPO - 249 (23.77 t/ha), JHO - 95 - 2 (23.24 t/ha), JHO - 95 - 1 (23.15 t/ha) and OL - 970 (22.84 t/ha) were statistically at par with the Check Kent (25.0 t/ha) for green fodder yield.

Varietal evaluation of sorghum genotypes

(M.S. Raut)

Sweet sorghum genotypes SSV-84 produced significantly highest green forage (75.32 t/ha) and dry matter yields (20.03 t/ha) followed by SSV-12611, Ruchi

and DFJ-1 (check) in multicut management.

Varietal evaluation of berseem

(M.S. Raut)

Three diverse collections of berseem (*Trifolium alexandrinum*) viz. JHB-1SB-86 (Mescavi), IL-40010 (Falili) and IL-40016 (Saidi) were evaluated. The green forage yield from single harvest varied marginally (16.8 to 17.6 t/ha), while considerable variation was observed in terms of dry matter yield (4.10 t/ha in Saidi to 6.04 t/ha in Falili). The highest dry matter yield was recorded in IL-40010 (6.04 t/ha) followed by JHB-15B-S-6 compared. The seed setting was considerable in all the collections.

SRS-4 : GENETIC IMPROVEMENT OF FODDER BAJRA AND BAJRA X NAPIER HYBRIDS FOR QUALITY AND PRODUCTIVITY

(D.H. Sukanya and P.K. Jayan)

Sixty diverse napier germplasm and eight variable fodder bajra lines were utilized in making inter-specific crosses. One hundred and eighty two hybrids have been selected for further critical evaluation.

Preliminary evaluation of clonal population of Bajra x Napier hybrids

One hundred and eight hybrids were evaluated with the checks NB - 21, IGFRI - 7 and superior hybrids identified for the region are PBN - 16 and CN - 8. These selected hybrids had good tillering ability with tiller synchrony and a lot of variability for various attributes. Green fodder yield of the hybrids ranged from 8 - 49.7 kg per 6 m row, many of them superior to checks.

Genetic variability in selected Bajra x Napier hybrids

Significant variability existed among selected 32 inter - specific hybrids for all the characters except for green and dry fodder yields. Plant height ranged from 2.7 - 4.4 m, leaf length (54.1 - 116.8 cm), leaf width (3.0 - 4.7 cm), stem diameter (2.0 - 3.2 cm), leaf - stem ratio (0.4 - 3.25), green fodder yield (49.7 - 81.9 t/ha) and dry fodder yield (17.5 - 32.2 t/ha).

Stability of Bajra x Napier hybrids

Five newly synthesized hybrids (DHN - 1, DHN - 2, DHN - 3, DHN - 4, DHN - 5) were found to be stable in all the three cuts encompassing monsoon and winter seasons. Many of the highly productive hybrids indicated their suitability to favourable conditions i.e., monsoon. Some hybrids were found to be suitable for low yielding or unfavourable environment i.e., winter with moisture stress condition

Combining ability for fodder yield and related characters in interspecific hybrids

Interspecific hybrids produced involving three diverse fodder bajra lines (PP 405A (Cms line), Giant Bajra, Sweet Bajra) and ten diverse napier lines were evaluated.

Significant variability existed among hybrids for most of the traits. Comparatively higher contribution of bajra for plant height, number of nodes, internodal length and by Napier genotypes for leaf length, leaf width, Stem diameter, Green fodder and dry fodder yield were recorded. But overall result indicated the higher contribution of interaction component for most of the traits indicating the importance of specific combining ability.

Genetic diversity in Napier grass

On the basis of Mahalanobis D^2 analysis, 55 genotypes were grouped into six clusters. It was found that geographical diversity is not related to genetic diversity and selection of genotypes for hybridization should be based on genetic diversity rather than geographic diversity.

SRS-5: PRODUCTIVITY AND PERSISTENCY OF TROPICAL GRASS/LEGUME ASSOCIATIONS

(P.K.Jayan and M.S.Rant)

The study on productivity and persistency of grass/legume associations on grasses viz. *Sehima nervosum, Heteropogon contortus* and *Dichanthium annulatum* (0, 20, 40 and 60 kg/ha fertilization) and introduction of legumes viz. *Stylosanthes hamata, Stylosanthes scabra, Centrosema pubescens* and *Macroptelium atropurpurium*

Legumes in mixtures with grasses increased herbage yield from 5.5 to 16.3 per cent in *D. annulatum*; from 5.0 to 24.1 per cent in *H.contortus*; and from 14.2 to 26.1 per cent in *S. nervosum* over grass grown in monoculture under 60 kg N/ha fertilization. Herbage yields of mixtures were recorded highest in grasses grown in association with *M. atropurpureum* followed by *S. scabra* and same was lowest in *S. hamata*. Persistency of *S. scabra* in association with grasses recorded highest values, while same was low in *S. hamata*.

Studies on agro silvipastoral systems

(M.S. Raut)

The experiment continued in the second year. The mixtures of *Stylosanthes scabra* with four grasses viz. Trispecific napier hybrid, *Brachiaria decumbens, Pennisetum pedicellatum* and *Cenchrus ciliaris* cv. S-3108 along with sole *S. scabra* were grown in association with the fodder trees viz. *Hardwikia binata* and *Leucaena luecocephala* and without the tree component. The mixture of trispecific napier hybrid and *S. scabra* (13.16 t/ha total dry matter yield) out yielded the other grass + stylo mixtures and sole stylo in both the fodder tree associations as well as in without tree component. The highest of total green forage yield (40.93 t/ha), however, was recorded with *Pennisetum pedicellatum* + *Stylosanthes* with and without tree components.

SRS-7 : INTEGRATED WEED MANAGEMENT IN *STYLOSANTHES HAMATA* SEED PASTURE

(V. Ramamurthy)

Sowing of *Stylosanthes hamata* 20 days after blanket spray (DABS) of Oxyflurofen

or 2, 4 - D as a pre emergent found superior over 7, 15 and 30 DABS. Among the doses of Oxyflurofen, 0.2% ai/ha recorded significantly lower dry weight of monocot and dicot weeds and 0.25% ai/ha significantly affected the germination and growth of *Stylosanthes hamata*. The spray @ 0.05 to 0.1% Oxyflurofen ai/ha seems to be the best when *Stylosanthes hamata* was sown 20 days after blanket spray of Oxyflurofen.

Pre emergent spray @ 0.75 kg 2, 4 - D ai/ha was found superior in controlling monocot and dicot weeds.

The integrated approach to control weeds in *Stylosanthes hamata* indicated that weed free condition throughout the crop growth recorded highest seed yield of 0.61 t/ha. Among the herbicides, 2, 4-D as post emergent spray at the rate of 0.75 kg ai/ha was found superior. Thus, 2, 4-D at the rate of 0.75 kg ai/ha as a post emergent and integrated methods like harrowing, hand weeding and herbicides are the best weed management practices for *Stylosanthes hamata* seed pasture.

FODDER PRODUCTION FOR INTENSIVE DAIRY FARMING

Studies on Agronomic aspects of perennial cereal/legume intercropping systems and Agro-silvipastoral systems

(M.S. Raut)

Intercropping of annual/perennial fodder crops with legumes

The intercropping systems consisting the combinations of two perennial cereal forages viz. Napier bajra hybrid cv. IGFRI-3 and *Panicum maximum* (Guinea cv. Hamil), and two intercrop treatments viz. lucerne cv. RLS-88 round the year and cowpea (cv. DFC-1) - oat (cv. OL-125) in sequence were evaluated at four planting patterns of perennial cereal forages viz. normal planting at 1-00 m x 0.50 m, Skipped 1 row, Skipped 2 rows and paired planting (0.50 m : 1.50 m : 0.50 m), along with the sole crops of napier-bajra hybrid, guinea, lucerne and cowpea - oat.

The maximum green forage yield (89.2 t/ha) and dry matter yield (25.9) t/ha) were recorded with the intercropping system involving the napier bajra hybrid planted at 1.00m x 0.50m and intercropped two rows of cowpea in the *kharif* season and one row of oat in the *rabi* season which was 24.2 and 205.6 per cent higher than sole crops of napier-bajra hybrid and cowpea-oat, respectively in terms of green forage production. The intercropping of cowpea in napier-bajra hybrid planted at 1.00m x 0.50m resulted in the highest LER (1.635) during *kharif* season, while, the intercropping of oat in guinea planted at skipped 1 row registered the maximum LER (2.1>4) during *rabi* season.

SRS-6 : INTEGRATED NUTRIENT MANAGEMENT IN FODDER PRODUCTION SYSTEMS

6.1 Effect of organic matter, nitrogen and biofertilizer on growth and productivity of napier x bajra hybrids

(V. Ramamurthy and D.H.Sukanya)

A field study consisting of three hybrid

Napier-Bajra viz., PBN-16, CO-2 and IGFRI-7, two levels of organic matter (0 and 10 t/ha) in main plots and three levels of nitrogen (100, 150 and 200 kg/ha/yr) and with and without *Azospirillum* inoculation in sub plots was started in June, 1995 under irrigated conditions. So far four harvests are done and results revealed that CO-2 recorded higher green forage of 61.5 t/ha in four cuts as compared to IGFRI-7 (58.7 t/ha) and PBN-16 (47.5 t/ha). IGFRI-7 recorded higher green forage in moisture stress periods than CO-2 and PBN-16. The leaf to stem ratio was maximum with PBN-16.

Application of 10 t organic matter recorded nearly 15 per cent yield advantage over control. Further, there is scope to reduce the nitrogen levels from 200 Kg N/ha to 100 kg N/ha with 10 t of and *Azospirillum* inoculation.

Azospirillum inoculation recorded higher green forage yield of 57.3 t/ha than control. Genotype differences was observed among the hybrids and IGFRI-7 showed higher response to *Azospirillum* inoculation followed by PBN-16 and CO-2.

6.2 Effect of nitrogen levels and *Azospirillum* on growth and yield of *Pennisetum* trispecific hybrid

(V. Ramamurthy)

The experiment comprised four levels of N (0, 25, 50 and 75 Kg N/h) and three *Azospirillum* inoculation treatments (control, ACD-15, ACD-20) for *Pennisetum* trispecific hybrid (*P. americanum* x *P. purpureum* x *P. squamulatum*) under rainfed conditions (Table 44).

Application of 75 kg nitrogen recorded higher, but nonsignificant green forage yield than other levels. Inoculation of *Azospirillum* cv. ACD-20 recorded significantly highest green forage yield as compared to ACD-15 and control.

The interaction effect of *Azospirillum* inoculation and nitrogen indicated that ACD-20 with 25 kg N/ha recorded significantly higher green forage yield as compared to other combinations, but, this showed that one can reduce the fertilizer N level up to 25 kg N/ha with *Azospirillum* inoculation.

Table 44 : Total Green forage of (4 cuttings) *Pennisetum* trispecific hybrid as influenced by interaction of Nitrogen and *Azospirillum* inoculation

	Nitrogen (Kg/ha)				
Treatment	0	25	50	75	Mean
Control	25.3	28.0	33.5	41.7	82.1
ACD-15	34.8	36.4	37.9	33.0	35.5
ACD-20	38.6	46.6	34.8	43.7	40.9
Mean	32.9	37.0	35.4	39.5	

C.D. at 5% for *Azospirillum* 4.09
C.D. at 5% for interaction 8.18

MONITORING OF DISEASES AND INSECT PESTS OF NATURAL AND CULTIVATED FODDER IN DIFFERENT CROPPING SYSTEMS

(C. R. Ramesh)

Disease of cultivated fodder species

In sorghum *Colletotrichum* leaf spot was

observed the incidence of which increased during October and November. Apart from *Colletotrichum, Macrophomina* root rot at the seeding stage was also observed. In cowpea leaf spot and collar rot was the major problem. During the post-monsoon period in Lucerne, pythium root rot, and Rhizoctonia stem rot was observed. In pearl millet fodder type, downy mildew was observed for the first time. In one of the napier parental lines, Helminthosporium leaf spot was very severe. Downy mildew was noticed on sorghum and Maize fodder types at Tiptur and Coimbatore Apart from these two diseases root rot and stem rot was also noticed on Sorghum and Maize at Coimbatore. Severe Cercospora leaf spot was observed on Amaranthes accessions at Trivandrum.

Regarding the inset pests, severe Aphid infestation was noticed on lucerne at Tegur, Tiptur and Coimbatore At Coimbatore the infestation was so severe that the accessions of LLS series was completely wiped out. Another important insect post noticed was Gundhibug pest of rice found feeding on seeds of guinea at Coimbatore.

Diseases of range grasses

In Sehima nervosum symptoms of zonate olighing of the leaf and drying up from the tip of the leaves were noticed. However, the damage to the clumps was due to rotting of root and collar portion.

Witches broom symptom was noticed in *Heteropogon contortus* during June, July to August. The microscopic observations of the ergot bodies revealed the formation of pycnidia of *Epichloe strangulium.*

Rotting of plants, either by drying of healthy plants or shedding of leaves was noticed in patches during the month of June in a pasture of *Stylosanthes hamata*, *S. scabra* and *S. scabra viz.,* fitzroy. Upon examination the collar portion of the diseased plants showed fungal growth and collar dry rot (dry rot). Examination of the dry rot specimens showed the association *Macrophomina* sps. in all the diseased material of *S. hamata* and *S. scabra* fitzroy. In *S. hamata* rotting was also due to *sclerotium* species.

The pitting d in *S. scabra* stem revealed the association of *Fusarium* species.

Anthracnose symptoms was noticed in *S. hamata* on leaves and *S. scabra* on leaves and stem and *S. hamata*, tetraploid on leaves, stem and inflorescence. The inflorescence was heavily infected and in such cases no flower formation was noticed. The Anthracnose symptom also showed variation in lesion size of different *Stylosanthes* species, which revealed the association of *Colletotrichuim glocosporioides.*

The disease symptoms resembling *Colletotrichum* was observed on commercial crops plants like Chilli, Tomato and cultivated Sorghum, all hosts of *Colletotrichum* which were allowed to dry up *in situ* to increase the inoculum.

In *S. scabra* bacterial leaf spot was noticed, and wilting of plants was noticed.

In *S. scabra* and *S. hamata*, tetraploid viral symptoms similar to that of alfa alfa or cowpea mosaic was noticed during the month of May and June. The incidence increased in July and August.

In *Siratro* and *Phaseoles lathyroides* bean yellow symptoms was observed.

ASSESSMENT OF DISEASES AND THE CONTROL IN MAJOR PASTURE LEGUME PRODUCTION

(C.R.Ramesh)

Severe infestation of leaves and stem was noticed in *Stylosanthes hamata* during June/July which continued up to December. Leisons on inflorcence leaf and stem was noticed in *S. hamata* cv. Verano during December. The fungus was identified as *Colletotrichum glocosporioides*.

Nineteen accessions of *S. scabra S. hamata, S. guianensis* and *S. viscosa* were raised in cement rings filled with soil collected, where stylo was not cultivated. Type B Symptoms were observed on *S. guianensis* accessions.

Incidence of heliocoverpa in stylo seed crop

Heliooverpa armigera (Hubner) (Noctuidae; Lepidoptera) was found voraciously feeding on the inflorescence, especially of flower parts and young ovules. In a 2nd year crop of *S. scabra* the larvae frequency was 1 to 2 per plant, in general and even up to 30 - 35/plant. Adjoining plot of stylo cv. Verano was found virtually from free from the pest. However, late flowering cv. fitzroy was also found infested at a medium level. Extensive observations during October/ November in the old crop of the scabra revealed the death of due to fungi as *Nomurea rileyi*. All the instars of the larvae were found infected and dead attached to the plant invariably near the inflorescence. However, the cadavers of the first few instars were not covered with the fungal spores where as, the matured larvae was densely covered with the spores giving bluish green appearance to the cadavers. The incidence continued up to the end of November. The fungal infestation of the *Helicoverpa* larvae was not observed during July/August sown *S. scabra* plot which is about 300 meters away from the epizoptic point.

Larval parasites of Heliothis in Stylosanthes seed crop

Out of 110 larvae collected from stylo seed crop sown during June-July, 12 died and the rest were reared. The techinid flies were collected and sent for identification to U.A.S., Bangalore. Two species of Techinid flies were identified viz. *Carcelia illata* (Curian) *Goniophthalamus halli* mersil.

Survey of Stylo seed producing villages

Survey was conducted in 25 villages coming under Gorantla, Penukonda, Chilmathur, Hindupur and Somandepalli mandals of Ananthapur District in Andhra Pradesh and Bagepalli area in Karnataka.

Spike blight, stem cankering symptoms of Anthracnose were observed both in *S. hamata* and *S. scabra*.

At Bagepalli and Narepalli in Karnataka parthenium smothered *S. hamata* seed crop.

At Govt. farm and farmer's field low yield was anticipated due to drought and also "Peculiar disease" similar to Anthracnose. The *S. scabra* crop had very severe blight symptoms resulting in drying up of spikes.

Farmers at Palasamudram and Somandapalli expressed that during October the *scabra* plot was infested with a green caterpillar similar to *Heliothis armigera*.

At Bovinapalli, in *S. scabra* plot severe rat infestation was observed with number of rat burrows. The same plot of *S. scabra* plants were also heavily infested with white ants.

At Somandapalli, *S. scabra* cultivated under irrigation showed symptoms of sclerotium blight and anthracnose.

Breeder seed production of grasses and legumes (cultivated/ range)

About 9.6 t seed was produced 10 ha land under sown pastures of range legume *Stylosanthes* species viz. *S. hamata* cv. Verano, *S. scabra* cv. Sica and *S.scabra* cv.

Cenchrus ciliaris cv. 3108 pastures established during the year 1991 gave nearly 40 kg seed.

Extension and training

Regional station organized field day in association with U.A.S. Dharwad during September 1995 and an exhibition was setup.

Regional station collaborated with Extension unit of UAS Dharwad is extension education, training and also field demonstration etc. in popularizing forage production from grassland and farming systems to farmers of the region. Hybrid Napier entry PBN - 16 as well as promising range grasses were taken up under farm trial in eight locations in Dharwad district.

Training was imparted to officials of state soil conservation and watershed project.

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VISITS ABROAD

The following scientists visited abroad during the year :

Name	Period	Place
Dr. P.S. Tomar, Principal Scientist	20.04.95 - 06.05.95	UK & The Netherlands
Dr. R.K. Jain, Sr. Scientist	20.04.95 - 06.05.95	UK & The Netherlands
Dr. R.S. Upadhayay Sr. Scientist	15.03.96 - 14.09.96	UK
Dr. J.P. Singh Scientist	15.03.96 - 14.09.96	UK
Dr. A.K. Patra Scientist	15.03.96 - 14.09.96	UK

DISTINGUISHED VISITORS

Dr. R.S. Paroda,
Secretary (DARE) &
Director-General,
ICAR, New Delhi

Dr. E.A. Siddiq,
Dy. Director General (CS)
ICAR, New Delhi

Sh Arvind Netam
Minister of State for Agric. & Co-operative
G.O.I., New Delhi

Dr. Fernands Riveros
Cheif Grassland Science,
FAO, HQ, Rome, Italy

Sh. Vinay Shankar
Secretary, Department of
Rural Development & Wasteland
G.O.I., New Delhi

Dr. B.K. Soni
Ex-DDG(AS), ICAR
Chairman, QRT
Ulsoor Lake,
Banglore

Dr. B.D. Patil
Ex-Director, IGFRI
Member , QRT
Kothrud, Pune

Prof. V.P. Gupta
Prof. of Genetics
Member, QRT
PAU, Ludhiana

Dr. G.P. Lodhi
Prof. of Plant Breeding
Member, QRT
CCS HAU, Hissar

Prof. N.P. Melkania
Prof. of Ecosystem
Member, QRT
IIFM, Bhopal

Dr. B.M. Singh
Dean, HPKVV
Member QRT
Palampur

Dr. R.P. Singh
Ex-Director, CRIDA
Chairman, RAC
Jodhpur

Dr. Panjab Singh
Joint Director (Research)
IARI, New Delhi

Dr. J.P. Tondon
Assistant Director General
ICAR, New Delhi

Dr. K.L. Mehra
Ex-Director, NBPGR
Member, RAC
New Delhi

Dr. M. Ahluwalia
Member, RAC
New Delhi

Dr. S.N. Desai
Ex-Director of Ext. Education, MPKV
Member, SRC
Rahuri

Dr. S.K. Arora
Dean, CCSHAU
Member, SRC
Hissar

Dow Cameron
CSIRO, Brisbane,
Australia

Sukumar Chakraborty
CSIRO, Brisbane,
Australia

Dr. John Farrington
Consultant, ODI
London

Prof. R.J. Haggar
Technical Co-ordinator
Indo-UK Project
IGER, UK

Dr. N.R. Sackville Hamilton
Head, Plant Genetic Resource
ODI, London

Dr. S. Jarvis
Head, Soil Science
ODI, London

Dr. M. Theodoron
Head, Rumen Microbiology
ODI, London

Ms. Cathryn Turton
ODI, London

Ms. Pari Boumann
ODI, London

Dr. J.T. Nankar
Consultant
Marketing & Consultancy Service
Pune

Mr. Suraj R.
Director, Marketing & Consultancy
Service, Pune

Ethopian delegates

Mr. Bashir Haji Mohammed
Mr. Muctar Bashir Osman
Mr. Tensay Teshome Tedela
Mr. Rabale Said Nur
Mr. Semere Beyene
Ms. Amina Mohammed Daib
Mr. Omer Jibril Fahiye
Mr. Beiruk Kabtamu
Mr. Zeleke Silishi
Mr. Gebru Bonger

APPENDIX-I

LIST OF STAFF

Director — Dr. Bhag Mal, (w.e.f. 9.1.96)
Dr. R.P. Singh, (upto 8.1.96)

I. SCIENTIFIC

Division of Plant Improvement

S.R. Gupta, Ph.D., Principal Scientist (Economic Botany) & Head of Division (upto Oct., 95)
S.N. Zadoo, Ph. D., Principal Scientist (Genetics & Cytogenetics) & Head of Division (w.e.f. Nov., 95)
C.B. Singh, Ph.D., Sr. Scientist (Plant Breeding)
R.N. Choubey, Ph.D., Sr. Scientist (Plant Breeding)
S.N. Tripathi, Ph.D., Sr. Scientist (Genetics & Cytogenetics)
Devendra Singh, M.Sc., Sr. Scientist (Plant Breeding)
M.G. Gupta, Ph.D., Sr. Scientist (Genetics & Cytogenetics)
O.P. Dixit, M.Sc.(PGR), Sr. Scientist(Plant Breeding)
U.P. Singh, M.Sc., Sr. Scientist (Economic Botany)
B.S. Chaudhary, M.Sc., Sr. Scientist (Plant Breeding)
K.S. Kohli, Ph.D., Sr. Scientist (Plant Breeding)
D. N. Singh, Ph. D., Sr. Scientist (Plant Breeding)
U. S. Mishra, M.Sc., Scientist (Plant Breeding)
D.R. Malaviya, Ph.D., Scientist (Plant Breeding)
Ajoy Kumar Roy, Ph.D., Scientist (Genetics & Cytogenetics)
Sanjeev Gupta, M.Sc., Scientist (Plant Breeding)
Sanjay Gupta, M.Sc., Scientist (Genetics & Cytogenetics)
Vishnu Bhatt, M.Sc., Scientist (Plant Breeding) (w.e.f. 24.7.95)
B. Venkesh Bhatt, M.Sc., Scientist (Plant Breeding) (w.e.f. 24.7.95)
D.K. Agarwal, M.Sc., Scientist (Plant Breeding) (w.e.f. 24.7.95)
P.K. Katiyar, Ph.D., Scientist (Plant Breeding) (w.e.f. 24.7.95)
Ms. C.N. Neeraja, M.Sc., Scientist (Genetics & Cytogenetics) (w.e.f. 31.7.95)
P.K. Kaushal, Ph.D., Scientist Scientist (Genetics & Cytogenetics) (w.e.f. 30.9.95)
S.V. Sai Prasad, Ph.D., Scientist (Plant Breeding) (w.e.f. 26.12.95)
K. Sridhar, Ph.D., Scientist (Plant Breeding) (w.e.f. 31.12.95)

Division of Agronomy

R.P. Singh, Ph.D., Principal Scientist (Agronomy) & Head of Division
N.P. Shukla, Ph.D., Sr. Scientist (Agronomy)
S.N. Tripathi, M.Sc;, Sr. Scientist (Agronomy)
K.P. Niranjan, M.Sc., Scientist (Agronorny)
S.D. Gupta, M.Sc., Scientist (Agronomy)
Banwari Lal, M.Sc. Scientist (Agronomy) (on study leave)
Atar Singh, Ph.D., Scientist (Agronomy)
R.L. Arya, Ph.D., Scientist (Agronomy)
K.C. Sharma, M.Sc., Scientist (Agronomy)
Rajeev Kumar Agarwal, M.Sc., Scientist (Agronomy) (on study leave)
P.K. Pathak, M. Tech., Scientist (FMP)
J.B. Singh, Ph.D., Scicntist (Ag. Meteorology)
Ms. K.S.K. Kastoori Krishna, M.Sc., Scientist (Agronomy) (w.e.f. 24.7.95)
K. Shankar Narayan, M.Sc., Scientist (Agronomy) (w.e.f. 31.7.95)
G. Suresh, M.Sc., Scientist (Agronomy) (w.e.f. 24.7.95)
Ms. Leela Rani, M.Sc., Scientist (Agronomy) (w.e.f. 1.10.95)
Shiv Dhar, M.Sc., Scientist (Agronomy) (w.e.f. 8.11.95)
Dinesh Kumar, M.Sc., Scientist (Agronomy) (w.e.f. 21.11.95)

Division of Grassland Management

Vinod Shankar, Ph.D., Principal Scientist (Economic Botany) & Head of Division
B.K. Misri, Ph.D., Sr. Scientist (Economic Botany)
B.K. Trivedi, Ph.D., Sr. Scientist (Economic Botany)
J.N. Gupta, Ph.D., Sr. Scientist (Economic Botany)
S.S. Parihar, Ph.D, Sr. Scientist (Economic Botany)
Jai Prakash Singh, Ph.D., Scientist (Economic Botany)
J.P. Singh, Ph.D., Scientist (Geography)
Dipankar Saha, M.Sc., Scientist (Economic Botany)
S.K. Soam, Ph.D., Scientist (Economic Botany)
Ms. Anjali Kak, M.Sc., Scientist (Economic Botany)
Shiv Nath Ram, M.Sc., Scientist (Agronomy)
H.N. Subudhi, Ph.D., Scientist (Economic Botany) (w.e.f. 20.6.95)

Division of Agro-Silvipasture

P.S. Pathak, Ph.D., Principal Scientist (Economic Botany) & Head of Division (upto 1.1.96)
R.C. Singh, Ph . D., Sr. Scientist (Agronomy) & Head of Division (w.e.f. 2.1.96)
M.M Roy, M.Sc., Sr. Scicntist (Economic Botany)
S.K. Sharrna, Ph.D., Scientist (Horticulture)
S.K. Gupta, M.Sc., Scientist (Economic Botany)
T.A. Khan, M;Sc., Scientist (Statistics)
Sudhir Kumar, Ph.D., Scientist (Horticulture)
Sunil Kumar, Ph. D., Scientist (Horticulture)
Gulshad Mohammad, M.Sc., Scientist (Econamic Botany)
Ms. Sindhu Sarin, Ph.D., Scientist (Genetics & Cytogenetics) (w.e.f. 13.9.95)

Division Soil Science

R.K. Tyagi, Ph.D., Sr. Scientist (Geography) & Head of Division
M.R. Pahwa, Ph.D., Sr. Scientist (Microbiology)
S.B. Tripathi, Ph.D., Sr. Scientist (Soil Sciencc)
O.P.S. Panwar, M.Sc., Sr. Scientist (Soil Science)
Raj Bahadur Yadava, Ph.D., Scientist (Soil Science)
Pradeep Behari, M.Sc., Scientist (Physics)
A.K. Patra, Ph.D., Scientist (Soil Science)
S.K. Dass, M.Sc., Scientist (Ag. Chemistry) (w.e.f. 5.8.95)
S.K. Rai, M.Sc., Scientist (Ag. Meterology) (w.e.f. 13.9.95)
D. Burman, M.Sc., Scientist (Soil Water Conservation) (w.e.f. 28.9.95)
S. Bandhopadhyay, M.Sc., Scientist (Soil Water Conservation) (w.e.f. 28.9.95)

Division of Plant Animal Relationship

V.S. Upadhyay, Ph.D., Principal Scientist (LPM) & Head of Division (upto 4.10.95)
V.C. Pachauri, Ph.D., Principal Scientist (Animal Nutrition) & Head of Division (w.e.f. 5.10.95)
A. P. Singh, Ph.D., Principal Scientist (Agricultural Chemistry)
R. S. Upadhyay, Ph.D., Sr. Scientist (Animal Nutrition)
N.C. Verma, Ph.D., Sr. Scientist (LPM)
A. B . Majumdar, Ph .D ., Sr. Scientist (Bio-Chemistry)
B.K. Bhadoria, Ph.D,. Sr. Scientist (Organic Chemistry)
L.K. Karnani, M.Sc., Scientist (Agricultural Chemistry)
Smt..Suruchi Suresh Madav, M.Sc., Scientist (Organic Chemistry)
N.P. Singh, M.Sc., Scientist (LPM)
S.B. Maity, M.Sc., Scientist (LPM)

S. Radotra, M.Sc., Scientist (LPM)
A.K. Mishra, Ph.D., Scientist (LPM)
B. Srinivas, Ph.D., Scientist (Animal Nutrition)
K.K. Singh, Ph.D. Scientist (Animal Nutrition)
N.A. Shakil, M.Phil., Scientist (Organic Chemistry)
M.M. Dass, M. V. Sc., Scientist (Animal Nutrition)
P.N. Dwivedi, M.Sc., Scientist(Animal Nutrition)
A.K. Samanta, M.Sc., Scientist (Animal Nutrition)
F.C. Tuteja, M.V.Sc., Scientist (Vet. Medicine) (w.e.f. 24.7.95)
Sultan Singh, M.Sc., Scientist (Animal Nutrition) (w.e.f. 24.7.95)
A.S. Negi, M.Sc., Scientist (Organic Chemistry) (w.e.f. 24.7.95)
S.K. Mahanta, M.Sc., Scientist (Animal Nutrition) (w.e.f. 31.7.95)
Anil Kumar, M.Sc., Scientist (Biochemistry) (w.e.f. 29.9.95)
Ms. Jyotsna Dhingra, M.Sc., Scientist (Biochemistry) (w.e.f. 29.9.95)
G.H. Pailon, M.Sc., Scientist (Animal Nutrition) (w.e.f. 31.12.95)

Divisin of Seed Technology

Menhi Lal, Ph.D., Principal Scientist (Agronomy) & Head of Division
S.N. Singh, Ph.D., Sr. Scientist (Plant Pathology)
O. P. S. Verma, M.Sc., Sr. Scientist (Plant Physiology)
S.M. Misra, M.Sc., Scientist (Soil Science)
G.K. Dwivedi, M.Sc., Scientist (Agronomy)
K.P. Singh, Ph.D., Scientist (Genetics & Cytogenetics)
Rakesh Seth, M.Sc., Scientist (Seed Technology) (w.e.f. 24.7.95)
Ms. C.H. Padmavathi, Ph.D., Scientist (Agricultural Entomology) (w.e.f. 21.9.95)

Division of Plant Physiology and Biochemistry

L.P. Mishra, Ph.D., Principal Scientist (Plant Physiology) & Head of Division
R.K. Bhatt, Ph.D., Scientist (Plant Physiology)
Sewa Ram, Ph.D., Scientist (Plant Biochemistry)
Amresh Chandra, Ph.D., Scientist (Plant Biochemistry)
M.A. Baig, M.Sc.,Scientist (Plant Physiology) (w.e.f. 29.6.95)
Ms. M. Anuradha, Ph.D., Scientist (Plant Physiology) (w.e.f. 24.7.95)
P.K. Mandal, Ph.D., Scientist (Plant Biochemistry) (w.e.f. 31.7.95)
Ms. Anjali Chatrath, Ph.D., Scientist (Plant Physiology) (w.e.f. 13.9.95)

Division of Plant Protection

S.T. Ahmad, Ph.D. Principal Scientist (Plant Pathology) & Head of Division
R.K.Jain, Ph.D., Sr. Scientist (Nematology)

S.A. Faruqui, Ph.D., Sr. Scientist (Entomology)
M.I. Azmi, Ph.D., Sr. Scientist (Nematology)
K. C. Pandey, M .Sc. , Sr. Scientist (Entomology)
N. Hasan, Ph.D., Sr. Scientist (Nematology)
R.B. Bhaskar, M.Sc., Sr. Scientist (Plant Pathology)
N.K. Shah, M.Sc., Scientist (Entomology)
Pradeep Saxena, Ph.D., Scientist (Plant Pathology)
Mrs. Sharmila Roy, M.Sc., Scientist (Entomology)
M.S. Saharan, M.Sc., Scientist (Plant Pathology) (w.e.f. 31.7.95)
S.K. Nag, M.Sc., Scientist (Agricultural Chemistry) (w.e.f. 31.8.95)

Division of Agricultural Engineering

P.D. Gupta, Ph.D., Principal Scientist (FMP) & Head of Division
R.B. Varshney, B.Tech., Sr.Scientist (Soil Water Engineering)
P.S. Chattopadhyay, M.Tech., Scientist (FMP) (on study leave)
Brajesh Singh, M.Tech., Scientist (FMP)
M.L. Gaur, B.Tech., Scientist (SWE) (on study leave)
R. K. Goyal, M.Tech., Scientist (Ag. Strucl. & Proc. Engg.) (on study leave)

Division of Rural Economics and Biometrics

D. P. Handa, Ph.D., Sr. Scientist (Statistics) & Head of Division (upto Sept.'95)
Ram Ashrey Singh, M.A., Scientist (Economics) & Head of Division (w.e.f. Oct.'95)
Ashok Kumar, M.Sc., Scientist (Statistics)
Sandeep Saran, Ph.D., Scientist (Agricultural Economics)
Mrs. Ranjitha P., M.Sc.,Scientist (Agricultural Economics) (w.e.f. 24.7.95)
Ms. Isabella Rani, M.Sc. Scientist (Agricultural Economics) (w.e.f. 29.11.95)

Division of Extension and Training

P.S. Tomar, Ph.D., Principal Scientist (Agronomy) & Head of Division
R.N. Dwivedi, M.Sc., Sr. Scientist (Agronomy)
Maharaj Singh, Ph.D., Scientist (Extension)
Manju Suman, Ph.D., Scientist (Extension)
M.B. Tamhankar, B.Tech., Scientist (FMP)
R.V. Singh, M.Sc., Scientist (Extension)
Mahavir Singh, M.Sc., Scientist (Extension)
Purushottam Sharma, M.Sc., Scientist (LPM) (w.e.f. 24.7.95)
Rakesh Kumar, M.Sc., Scientist (Agronomy) (w.e.f. 31.7.95)

Forage Project (Co-ordinating Unit)

C.R. Hazra, Ph.D., Project Coordinator (Forage Crops)
G.P. Shukla, Ph.D., Principal Investigator (Plant Breeding)
C.R. Rawat, Ph.D., Principal Investigator (Agronomy)

Khubi Singh, M.Sc., Sr. Scientist (Statistics)
Sunil Kumar, M.Sc., Scientist (Agronomy) (w.e.f. 13.9.95)

Regional Research Station, Avikanagar (Rajasthan)

Mallaya, Ph.D., Sr.Scientist (Economics) & I/C Station
Fateh Singh, M.Sc., Sr. Scientist (Agronomy) (on study leave)
B. Gangaiah, M.Sc., Scientist (Agronomy) (w.e.f. 27.9.95)

Regional Research Station, Dharwar (Karnataka)

P.K. Jayan, Ph.D., Sr. Scientist (Economic Botany) & I/C Station
C.R. Ramesh,Ph.D., Principal Scientist (Plant Pathology)
M.S. Raut, M.Sc., Sr. Scientist (Agronomy)
V. Rama Murthy, Ph.D., Scientist (Agronomy)
Ms. D.H. Sukanya, M.Sc., Scientist (Plant Breeding)
Ms. Nagaratha P. Biradar, M.Sc., Scientist (Agricultural Extension) (w.e.f. 24.7.95)

II. TECHNICAL

A.K. Srivastava, Technical Officer (T-7)
R.K. Verma, Veterinary Officer (T-7)
M.S. Sharma, Farm Manager (T-7)
Dodamani Amallappa, Instrumentation (T-7)
N.C..Srivas, Technical Officer (T-6)
G. R. Deshmukh, Technical Officer (T-6)
M.M. Rastogi, Technical Officer (T-5)
C.B. Mishra, Technical Officer (T-5)
S.K. Rajpali, Technical Officer (T-5)
R.B. Mathur, Technical Officer (T-5)
D.K. Bhutani, Technical Officer (T-5)
Ravindra Pal Singh,Technical Officer (T-5)
Shree Ram Sikanya, Technical Officer (T-5)
C.P. Gupta, Technical Officer (T-5)
Mahi Pal Singh, (T-5)
H.N. Sharma, Tcchnical Officcr (T-5)
B.L. Barodia, Technical Officer (T-5)
Pramod Kumar Dwivedi,Tcchnical Officer (T-5)
Ram Singh,Technical Officer (T-5)
Gyasi Lal,Technical Officer (T-5)
Kanhai Singh,Technical Officer (T-5)
G.P. Nigam,Technical Officer (T-5)

O.N. Arya, Technical Officer (T-5)
P.K. Karpe,Technical Officer (T-5)
Anil Kumar Srivastava (T-4)
Sunil Gupta, (T-4)
S.C. Richharya (T-4)
Indra Pal Singh (T-4)
Rajendra Singh Parihar (T-4)
Nar Singh (T-4)
Raj Kumar Sharma (T-4)
Mrs. Sandhya Bhargava (T-4)
R.P. Yadava (T-4)
A.K. Tomer (T-4)
H.K. Agrawal (T-4)
R.B. Bhondele (T-4)
P.K. Tyagi (T-4)
K.P. Rao (T-4)
Mrs. Seema Srivastava (T-4)
S.D. Singh (T-4)
A. K. Saxena (T-4)
B.K. Pandurangh (T-4)

III. ADMINISTRATIVE

Sanjay Kant, Senior Administrative Officer
A.V. Joseph, Sr. Fin. and Accounts Officer
H.C. Saxena, Administrative Officer
Gauri Shankar, Asstt. Administrative Officer
L.S. Sharma, Asstt. Administrative Officer
O.P. Dubey, P.A. to Director
S.N. Dubey, Superintendent
G. D. Dubey, Superintendent
Mrs. S.L Hukmani, Superintendent
Mrs. N. Arora, Superintendent
A.N. Nimje, Superintendent
N.L. Sinoriya, Superintendent
P.B. Nair, Senior Stenographer
C. Narayan, Senior Stenographer

1V. AUXILIARY

V.K. Litoria, Medical Officer

APPENDIX-II

Statement showing headwise expenditure during 1995-96

(Rs. in lakhs)

	Head	Non-Plan	Plan	Total
1.	Pay and allowances	332.51	15.09	347.60
2.	T.A.	4.20	1.00	5.20
3.	Recurring contingencies	33.84	84.46	118.30
4.	Non-recurring contingencies			
	Works	-	4.10	4.10
	Equipments	-	15.69	15.69
	Vehicles	-	-	-
	Others	-	13.66	13.66
	Total	**370.55**	**134.00**	**504.55**

Hon'ble Minister of State for Agriculture, Sh. Arvind Netam being appraised the technological developments in forage production during his visit to the Institute

Dr. R. S. Paroda, Secretary, DARE and D.G., ICAR and Dr. E. A. Siddiq, DDG (C.S.), ICAR during their visit to the Institute

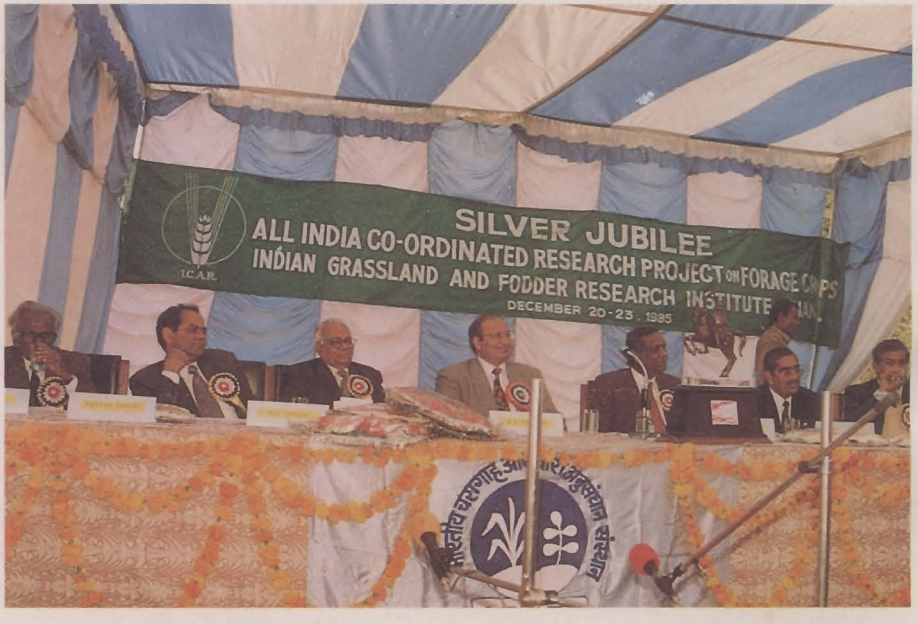
The QRT members reviewing farm activities

Dr. R. S. Paroda, Secretary, DARE and D.G., ICAR inaugurating the Phase-I expansion of the Institute Laboratory Complex

Dr. Bhag Mal on taking up his new assignment as Director

Workshop on Fodder Seed Networking - a view of delebration

A veiw of the 'Mahila Divas' organised as a part of transfer of technology programme



Delebrations during Silver Jubilee Function of AICRP (FC) organised by the Institute