PREFACE

I feel pleasure in presenting the Annual Report for the year 1993-94. The report covers brief account of the research work conducted in the divisions as well as at the regional stations.

During the year, Institute continued its efforts in evolving high yielding varieties of fodder and pasture crops, developing agrotechniques for optimising forage production from irrigated, rainfed and problem areas, maximization of biomass production from marginal and degraded lands through grassland management, silvipasture and agroforestry systems and development of improved farm implements. The research work on plant animal interface systems, harvest and post harvest technology was intensified.

I acknowledge the leadership and efforts of the then Director Dr. Panjab Singh for steering the research programmes. I hope this report shall be useful to research workers and development officials.

R.P. Singh
Director
GENERAL

INTRODUCTION

The limitations of research work in the field of grasses, grassland and fodder crops led to the establishment of Indian Grassland & Fodder Research Institute at Jhansi in the year 1962 by the Government of India. The Institute is being administered by Indian Council of Agricultural Research since 1966. In the past three decades of its existence it has made significant contribution in conducting, collating, and coordinating research, training and extension programmes on all aspects of forage production and utilization through inter-disciplinary research programmes in the field of forage plant improvement, grassland production and improvement, agro-silvipasture, agronomy, plant protection, post-harvest technology, seed technology and forage utilization and conservation. The traditional forage production system is under great threat due to land and input constraints. Therefore, the need has been felt to integrate forage production with the existing farming system as an essential component.

THE MANDATE

1. To conduct basic and strategic research on forage crops and grassland management.
2. To sustain, enrich and enhance germplam of these crops.
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, besides nine central units and three regional stations.


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 (ix) Medical Unit.
The Headquarter of All India Coordinated Project for Research on Forage Crops is located at this institute. The Institute houses research centers for All India Coordinated Research Project 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 Range Grasses and Legumes Seed Production (iii) NAEB Pasture Seed Storage in relation to its Quality (iv) NDDB supported Compaction, Storage and Transportation of Crop Residues and Grasses (v) NARP Training Programme (vi) NAEB Integrated Wasteland Development for Bundelkhand Region (vii) To study the utilization of *Sesbania aegyptica* grown under agroforestry system as animals feeds are also located at this Institute.

The new projects approved during the year are (i) Inter-Institutional Collaborative Network Programme on “Crop based Livestock Farming System” (ii) Inventory of Grazing System and Pastoralism in Ir.Jia (iii) Photosynthesis and Shade tolerance in tropical range grasses and legumes.

The Institute has an international project viz. IDRC-IGFRI Silvipasture Operational Research Project and another Indo-U.K. Collaborative Research Project has been initiated.

The Institute’s three regional stations 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 COLLABORATIONS**

The Institute has following collaborative research programme’s with various institutes/organizations at the national and international level.

**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 centers 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 centers in the country, one being at Jhansi.

**All India Coordinated Research Project on Dryland Agriculture**

The aim of this project is to carry out selection of suitable crops and varieties...
and develop agronomic practices which can increase production per unit area per unit time and make the most efficient use of stored soil moisture/ rain water under dryland conditions. The technology for increasing soil moisture storage, harvesting surplus rain water for protective / life saving irrigation and increasing the efficiency of stored soil moisture by suitable agronomic manipulations is being developed.

**All India Coordinated Research Project on Agroforestry**

This project aims at survey of existing agroforestry systems, collection, screening, selection and breeding of trees and bushes for agroforestry; and developing agroforestry systems and their management.

**All India Coordinated Research Project on Under - Utilized and Under-exploited Plants**

The centre functioning at the Institute is engaged in collection, evaluation, multiplication and testing of under-exploited and under-utilized plant species for various habitats and farming systems.

**AICRP on Farm Implements and Machinery Prototype Testing and Feasibility**

The centre is engaged in the testing of improved agricultural implements and farm machinery for forage based farming system and also for creating an awareness among the farmers for usefulness, handling and maintenance of improved implements.

**Breeder’s 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 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).

**NAEB Project on Range Grasses and Legumes Seed Production**

The National Afforestation and Eco-Development Board supported seed project on range grasses and legumes is functioning at IGRFRI Jhansi and Avikanagar CSWRI main campus, Pashulok Farm (U.P) and CAZRI, Jodhpur. The objectives of the project are to coordinate seed production activity of range grasses and legumes
in the country; to produce and distribute multiplied seed stock of range grasses and legumes through project centers in the country; and to provide training to technical personnel engaged in seed production of range grasses and legumes.

**NAEB Project for Studies on Pasture Seed Storage in relation to its Quality**

The National Afforestation and Eco- Development Board supported project for studies on pasture seed storage in relation to its quality has been initiated. The Plant Genetic Resources Conservation and Seed Testing Laboratory has been established.

**NDDB Project on Compaction, Storage and Transportation of Crop Residues and Grasses.**

This project has been taken up in collaboration with National Dairy Development Board to study physico- thermo mechanical properties of grasses and crop residues; to study the pressure moisture content and pressure density relationship; to develop equipment, process and techniques for densification; to conduct feasibility test of the developed technology in relation to location specific problems including its economic viability and commercialization of the technology developed.

**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 at this Institute.

**Utilization of Sesbania grown under Agroforestry System as Animal Feed**

The project aims at the productivity of *Sesbania sesban* grown in agroforestry system to study *in vitro* digestion kinetics and utilization of sesbania and companion crops including crop residues and to quantify nutrients yield per unit from sesbania based food-fodder production system.
NWDB Project on Integrated Development of Wasteland in Bundelkhand Region

One village Ambabai in Jhansi district (U.P.) and another village Chopra in Datia district (M.P.) were selected for the project. The whole village area (1381.0 ha) including 529.0 ha area of deforested land in the latter have been taken up for various improvement measures. Most of these wasteland areas belong to village Panchayat / Gram Sabha and Govt. agencies and some to private parties.

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 (including pasture and leaf fodder) and firewood production. The area representing typical wasteland has been rehabilitated through various silvipastoral system.

Projects approved/initiated

The following projects have been approved and initiated this year:

(I) Indo-U.K. Collaborative Research Project
(II) Cess Fund Project on Inventory of Grazing Resources, Grazing Systems and Pastoralism in India
(III) Cess Fund Project on Photosynthesis and Shade Tolerant Range Grasses and Legumes

STAFF

The Institute has a sanctioned strength of 244 Scientific, 138 Technical, 82 Administrative, 173 Supporting and 36 Auxiliary staff. The detailed staff position as on 31.3.1993 is appended. (Appendix I)

FINANCE

During the year 1993-94 the Institute utilized budget grant of Rs. 465.30 lakhs out of which Rs. 159.82 lakhs were utilized under the plan and Rs. 305.48 lakhs under non-plan. During the year, revenue of Rs. 8.77 lakhs was realised. The headwise expenditure is mentioned in Appendix II.
FACILITIES

Central Research Farm

The Institute farm has a total area of 574 ha including the area under campus and National Research Centre on Agroforestry. The farm has varying topography with rakar, parwa and kabar types of soils. The farm roads were recarpeted.

Administrative Wing and Research Laboratories

The Administrative Wing and Research Laboratories comprise of five laboratory wings and one administrative wing. There are well furnished Conference Hall and Committee Room for Symposia/Conferences etc. The laboratory wings have 51 sitting rooms and 25 laboratories well equipped with fixtures and furnitures and sophisticated instruments. The Central Analytical Laboratory and Central Instrumentation Laboratory provide services for chemical analysis and instrument repairs and maintenance.

Library

The Institute library accessioned 7043 books, besides, 100 reports/bulletions/books received on complementary basis during the year. The library subscribed for 90 Indian and 61 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 organisations and library consultation facility from time to time. The reprographical services are also available. The copies of the reprints of the articles are also sent free to the indentor of Indian as well as foreign agencies/organisations.

Photography & 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 suite Scientist Home is annexed with 25 rooms PG Training Hostel. The 3-suite VIP Guest House is catering to the needs of visitors.

Medical Unit

The Medical unit is located in the premises of the Institute with a Medical Officer and other auxiliary staff. The already available facilities were strengthened to provide better health care to the staff and their family members.

Weather

The year 1993 experienced normal onset of monsoon in 3rd week of June i.e. 25th standard meteorological week. Below normal rains were received in July and August in 11 and 7 rainy days respectively. The monsoon remained effective up to last week of September i.e. 39th standard week and very good amount of rain (324.3 mm) in 12 rainy days helped in growing rabi crops. Only 19.6 mm rainfall in 3 rainy days was received during rabi season.

The peak maximum temperature (47.0°C) on 10th June 1993 and peak minimum temperature (1.8°C) on 26th December 1993 were recorded. The highest values with respect to evaporation (14.8 mm/day) on 5th and 7th May, bright sunshine hours in a day (11.7 hrs) on 7th May and wind velocity (15.4 km/hr) on 19th May 1993 were recorded. Maximum values of soil temperature (57.5°C) at 5 cm depth (50.0°C) at 10 cm depth both on 12th June 93 and (40.0°C) at 20 cm depth on 9th and 12th June 93 were recorded at 14.16 hrs of the day (Table-1).
Table 1: Meteorological data at C.R. Farm IGFRI Jhansi

<table>
<thead>
<tr>
<th>Months</th>
<th>Temp °C</th>
<th>RH%</th>
<th>Rainfall (mm)</th>
<th>No. of Rainy Days</th>
<th>Wind Velocity (Km/hr)</th>
<th>Bright Hours/day</th>
<th>Evapotranspiration (mm/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 93</td>
<td>38.7</td>
<td>18.5</td>
<td>24</td>
<td>000.5</td>
<td>5.9</td>
<td>10.1</td>
<td>8.7</td>
</tr>
<tr>
<td>May 93</td>
<td>42.2</td>
<td>23.2</td>
<td>20</td>
<td>055.1</td>
<td>3</td>
<td>7.8</td>
<td>9.8</td>
</tr>
<tr>
<td>June 93</td>
<td>40.3</td>
<td>25.0</td>
<td>35</td>
<td>031.5</td>
<td>4</td>
<td>8.3</td>
<td>7.9</td>
</tr>
<tr>
<td>July 93</td>
<td>34.8</td>
<td>25.5</td>
<td>58</td>
<td>187.2</td>
<td>11</td>
<td>7.2</td>
<td>6.2</td>
</tr>
<tr>
<td>August 93</td>
<td>33.1</td>
<td>24.6</td>
<td>64</td>
<td>167.1</td>
<td>7</td>
<td>5.8</td>
<td>5.4</td>
</tr>
<tr>
<td>September 93</td>
<td>30.7</td>
<td>23.6</td>
<td>97</td>
<td>342.3</td>
<td>12</td>
<td>4.7</td>
<td>5.5</td>
</tr>
<tr>
<td>October 93</td>
<td>33.4</td>
<td>16.7</td>
<td>91</td>
<td>001.8</td>
<td>-</td>
<td>1.5</td>
<td>9.2</td>
</tr>
<tr>
<td>November 93</td>
<td>29.8</td>
<td>11.6</td>
<td>45</td>
<td>000.0</td>
<td>-</td>
<td>1.1</td>
<td>8.7</td>
</tr>
<tr>
<td>December 93</td>
<td>24.8</td>
<td>5.4</td>
<td>39</td>
<td>000.0</td>
<td>-</td>
<td>NA</td>
<td>7.7</td>
</tr>
<tr>
<td>January 94</td>
<td>23.2</td>
<td>8.0</td>
<td>94</td>
<td>015.8</td>
<td>NA</td>
<td>7.6</td>
<td>7.6</td>
</tr>
<tr>
<td>February 94</td>
<td>25.9</td>
<td>7.9</td>
<td>92</td>
<td>002.0</td>
<td>3</td>
<td>NA</td>
<td>9.3</td>
</tr>
<tr>
<td>March 94</td>
<td>35.0</td>
<td>13.4</td>
<td>78</td>
<td>000.0</td>
<td>2.5</td>
<td>10.2</td>
<td>6.2</td>
</tr>
</tbody>
</table>
DIVISION OF PLANT IMPROVEMENT

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

1.1 Grasses
(S.R. Gupta and Sanjeev Gupta)

Collection

207 new genetic material of grasses have been collected from southern India comprising *Dichanthium annulatum* (22), *D. caricosum* (20), *Sehima nervosum* (63) and other important grass species of forage value.

Evaluation

A wide range of variation was recorded in different growth parameters of *Chrysopogon fulvus*, *Sehima nervosum* and *Dichanthium annulatum*, (Table 2).

**Dichanthium annulatum**

'Nine selected lines of *D. annulatum* viz., IG 2172, IG 2225, IG 1985, IG 1981, IG 1949, IG 1958, IG 2004, IG 2169 and IG 2173 were evaluated in 4th year and included in coordinated trials.

**Sehima nervosum**

Four promising lines viz, IG 2045, IG 2052-2, IG 2037 and IG2040 were selected for multilocation trials.

Documentation

Computerized data base on different accessions of grasses has been prepared for long term storage in national gene bank and for further use.

<table>
<thead>
<tr>
<th>Species</th>
<th>Tiller height (Cm)</th>
<th>Fresh tussock wt (Kg)</th>
<th>No. of tillers in 500g (fwt)</th>
<th>L/S ratio (fwt)</th>
<th>L/S ratio (dwt)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Chrysopogon fulvus</em></td>
<td>128.6-182.4</td>
<td>1.06-1.95</td>
<td>30-120</td>
<td>0.58-1.10</td>
<td>0.72-1.90</td>
</tr>
<tr>
<td><em>Sehima nervosum</em></td>
<td>95.0-165.0</td>
<td>0.88-1.53</td>
<td>190-404</td>
<td>0.72-1.00</td>
<td>0.53-1.03</td>
</tr>
<tr>
<td><em>Dichanthium annulatum</em></td>
<td>110.2-204.6</td>
<td>0.55-0.92</td>
<td>48-240</td>
<td>0.42-0.85</td>
<td>0.44-0.96</td>
</tr>
</tbody>
</table>
1.2 Forage legumes

(U.P. Singh)

188 germplasm line were collected from Rajasthan, A.P. & Karnataka which includes

Medicago sativa (130)
Stylosanthes hamata (43)
S. scabra (07)
Lablab purpureus (04)
Trifolium alexandrinum (04)

Cowpea

In cowpea, 338 germplasm lines were evaluated against two national checks viz; Bundel Lobia-1 and UPC-5286. Wide range of variability was observed and on the basis of dry matter yield/plant, accession Hy-10, P36-1, Hy-6 P52-7, Hy-1068-8, Hy-5 P52-4, 338-A, 380, 380A and 1146 were found better.

Guar

IGFRI- 1539-1 and 23-1 were evaluated in final evaluation trial of AICRP against the control variety BG-1 during the year 1991-93. IGFRI-1539-1 out yielded the qualifying variety (BG-1) by 3.07, 6.68 and 20.03% more yield of GM, DM and Crude protein respectively (Table-3).

On the basis of three years data 1991-93, IGFRI-1019-1 variety out yielded HG-75 and Naveen by 6.67 and 10.90% more seed, 4.31 and 12.27% more gum yield respectively. Similarly 15.62 % more protein yield was recorded against check variety Naveen while it was at par with HG-75 (Table-4). Besides, this variety has already proven its superiority for forage yield and yield attributes during the year 1988-90. The variety was proposed for identification for release as dual type in AICRP (AL) workshop and accepted for consideration.

Besides these trials, 73 various accession of forage legumes viz. Desmodium species, Stylosanthes species, Centrocema species, Indigofera species, Clitoria ternatea, Macroptlium atropurpurem, Melilotus species and Vicia species were maintained in live nursery.

Breeder seed of released and prereleased varieties of guar viz; BG-1, BG-2 and IGFRI-1019-1 was produced at this centre.
Table 3: Performance of one variety IGFRI-1539-1 under AICRP (FC) for fodder production and the attributes 1991-93

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Green fodder yield (t/ha)</th>
<th>Dry matter yield (t/ha)</th>
<th>Crude protein yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>91</td>
<td>92</td>
<td>93</td>
</tr>
<tr>
<td>IGFRI-1539-1</td>
<td>19.6</td>
<td>23.4</td>
<td>24.7</td>
</tr>
<tr>
<td>Bundel guar-1</td>
<td>17.9</td>
<td>23.4</td>
<td>24.7</td>
</tr>
</tbody>
</table>

Table 4: Performance of Guar variety IGFRI-1019-1 under AICRP (AL) for seed/grain production and the attributes 1991-93

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Seed yield (q/ha)</th>
<th>Gum yield (q/ha)</th>
<th>Protein yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>91</td>
<td>92</td>
<td>93</td>
</tr>
<tr>
<td>IGFRI-1019-1</td>
<td>9.94</td>
<td>12.40</td>
<td>9.06</td>
</tr>
<tr>
<td>HG-75(Cg)</td>
<td>8.64</td>
<td>11.90</td>
<td>8.99</td>
</tr>
<tr>
<td>Naveen (C2)</td>
<td>9.49</td>
<td>11.50</td>
<td>7.54</td>
</tr>
</tbody>
</table>

PI-2: PRODUCTION AND QUALITY BREEDING IN FODDER GRASSES

2.1 Breeding superior varieties of forage sorghum

(D.S. Katiyar, U.S. Mishra and D.N. Singh)

Evaluation of germplasm: New accession from ICRISAT, and 38 unevaluated old materials were evaluated. Based on superiority in forage yield seventeen genotypes were identified for further testing.

Initial evaluation of promising strains for single and multicut systems: Fourteen superior strains selected from germplasm, suitable for single cut and multicut systems were evaluated using SSG-59-3 and HC 136 as controls.

For single cut, analysis of the data revealed that eight strains were superior over the check (H.C.136) out of which four namely IS 5262, 4425, 2472 and 20013 showed significant superiority.

For multicut system, analysis of data for the first cut revealed that five strains were 10% superior (IS 22386, 20751, 2472, 20013 and 2189) over the check SSG-59-3 and only one strain (IS 2189) was significantly superior.

Evaluation of M.S. Lines, Hybridization and advancing of filial generations Evaluation of M.S. Lines: 45 male sterile lines along with their maintainers were evaluated at 50% flowering. Following lines were found suitable for further use in forage breeding programme i.e. ICS-1, 3, 4, 5, 7, 11, 12, 15, 17, 28, 29,
Hybridization: using above selected twenty seven M.S. lines and eleven pollinators, 112 F\textsubscript{1} hybrids were obtained.

Advancing of filial generations: Large no. of hybrids/progenies were advanced and single plant progenies were selected. (Table 5)

Table 5 Details of the hybrid generation and their progenies

<table>
<thead>
<tr>
<th>Filial generation</th>
<th>No. of cross</th>
<th>No. of hybrids/progenies planted</th>
<th>No. of progenies selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>F\textsubscript{1}</td>
<td>43</td>
<td>43</td>
<td>60</td>
</tr>
<tr>
<td>F\textsubscript{2}</td>
<td>14</td>
<td>77</td>
<td>131</td>
</tr>
<tr>
<td>F\textsubscript{3}</td>
<td>12</td>
<td>31</td>
<td>41</td>
</tr>
<tr>
<td>F\textsubscript{4}ICRISAT</td>
<td>13</td>
<td>26</td>
<td>48</td>
</tr>
<tr>
<td>F\textsubscript{5}hybrids</td>
<td>7</td>
<td>22</td>
<td>85</td>
</tr>
</tbody>
</table>

Fifty-nine single plant progenies with high tillering were planted at F\textsubscript{4} stage and after rigorous selections 23 progenies were selected.

Multiplication: Twenty promising strains were multiplied for Institute programme and All India Co-ordinated programme.

ICRISAT collaborative programme: Evaluation of 108 F\textsubscript{1} hybrids for forage attributes and 13 genotypes from ICRISAT were evaluated in replicated trial.

All India Co-ordinated trial

Initial evaluation trial for single cut, 27 entries (IGFRI-2 entries).
Advanced varietal trial for single cut, 17 entries (IGFRI-4 entries)
Advanced varietal trial for multicut, 13 entries
Evaluation of sweet stalk, 9 entries. Besides the above trial HD\textsubscript{10} was also contributed for initial evaluation.

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 OATS**

1. Germplasm evaluation

Germplasm evaluation trial of oat accessions showed wide variations for various quantitative traits viz. days to 50% flowering (91-146), plant height (46.0-200.0 cm), leaf number/tiller (4-10), flag leaf length (8.0-55.0 cm), flag leaf width...
(0.8-3.1 cm), longest leaf length (19.0-63.0 cm), longest leaf width (0.8-3.8 cm), panicle length (8.0-70.0 cm) and number of spikelets/panicle (16-201).

2. Handling of segregating progenies

**F₆ Progenies**: The progeny performance of 110 lines in F₆ showed that some of the lines produced 8 to 17% more in green matter over the check.

**F₄ Progenies**: Out of two hundred nine lines of F₄ evaluated under multicut situation, some progenies exhibited superior performance varying from 12 to 22% over the check.

**Back cross progenies**: Of sixty five lines derived from interspecific crosses namely *Avena sativa* (OS--6) x *A. sterilis* and *A. sativa* (OS--6) x *A. maroccana* genotypes BC 432-7 of *A. sativa* x *A. maroccana* and BC (A. sativa x A. sterilitis)-D exhibited high regeneration ability along with 12 to 15% superiority in green forage yield over the checks.

**Amphiploid progenies**: 596 plant progenies including 201 of (UPO--94 x A. maroccana) 310 of (JHO 801 x A. maroccana) and 85 of (OS--6 x A. maroccana) were raised in A₉ generation. Characterization data were recorded for all the progenies, some selected progenies were screened for cytological parameters.

**Morphology**: Wide range of morphological variations for different parameters were observed in all the three crosses. A number of progenies were throwing segregants for certain traits in this generation (A₉) too. New combination of characters was observed in many progenies indicating breaking of tight linkages.

**Cytology**: Cytological analysis of 37 individual plants revealed ten different chromosome number out of 29 possible chromosomes numbers from a breakdown of amphiploid (2n = 10x = 70). All the ten different numbers i.e. 2n = 42, 43, 44, 56, 60, 64, 66, 68, and 70 were encountered in the amphiploid derivatives of JHO 801 x A. maroccana whereas all but one plant derived from amphiploid UPO-94 x A. maroccana had reverted back to the parental hexaploid number of 2n = 6x = 42.

About 20 per cent plants retain the original decaploid number of 2n = 10x = 70 in case of JHO 801x A.maroccana. till C₁₀ generation. However, UPO-94 x A. maroccana lines 91.6 percent of plants scored were found to have reverted back to 2n = 6x = 42.

The studies confirmed our earlier observation of different genotypes of
Asativa used in the crossing programme show different response as far as chromosomal stability/breakdown of poliploidy is concerned.

12.5 percent plants in JHO 801 XA. maroccana have more or less stabilised at $2n = 2x + 2 = 44$. The detailed meiotic studies revealed a constant occurrence of 22 bivalents indicating an addition of 2 alien chromosomes. Such plants have been indentified/isolated.

The morphological and quality parameters of such plants are being worked out. If found superior these can be directly utilized for transfer of such characters into other cultivated varieties of A. sativa.

Comparisons are also underway between original hexaploid UPO 94 and those derived from breakdown of amphiploid of crosses as to whether introgression for desirable traits has taken place.

All India Co-ordinated trials

(i) Initial varietal trial (multicut): Testing of three new strains JHO-891, 892 and 893 developed through inter varietal hybridization in North-West zone indicated that JHO-893 recorded superiority of 9.2% in GFY and 12.8% in DMY over the check. The strain also possessed high leaf/stem ratio.

(ii) Advance varietal trial (multicut): In Central zone JHO 881 showed 11.11% and 15.67% increase in GMY and DMY over the check respectively.

FORAGE PENNISETUMS

1. Interspecific hybridization in Pennisetum species

Interspecific hybridizations were attempted in following combinations with an objective to evolve new plant types:

(a) $F_1 (P. americanum \times P. orientale) \times P. squamulatum$
(b) $F_1 (P. americanum \times P. orientale) \times Trispecific Pennisetum hybrid$
(c) $F_1 \times P. americanum$
(d) $BC_1 \times P. americanum \times P. squamulatum$
(e) $BC_1 (X) \times P. americanum$
(f) $BC_2 (BC_1 \times P. americanum) \times P. squamulatum$
(g) $BC_2 \times P. americanum$
(h) $(P. americanum \times P. purpureum) \times P. squamulatum$
(i) $P. americanum \times P. squamulatum$
(J) *P. pedicellatum* (perennial) × *P. americanum*
(k) *Pennisetum* hybrid × *P. americanum*
(l) Trispecific hybrid × *P. sqamulatum*
(m) Trispecific hybrid × *P. americanum*

**Development of Amphiploid** : $F_1$ (*P. americanum* × *P. orientale*) plants were treated with colchicine in order to obtain amphiploid. Two plants were selected on the basis of morphological differences and are being studied further to confirm their chromosomal status.

(3) **All India Co-ordinated trials** : Three newly developed N.B. hybrids viz. BN 9201, 9202 and 9203 were being multiplied for testing in advance varietal trial during *kharif* 1994.

### 2.3 Improvement of forage maize

(B.S. Chaudhary)

Ninety one new accessions of indigenous fodder type maize were collected from South and North Bihar state (12 districts) during 1993. Sixty two genotypes/composites of fodder maize, collected during 1991 and 1992 were evaluated and selections were made.

In varietal crossing programme crosses have been attempted for high dry matter content with 25 genotypes/selections using African Tall as female parent.

**PI-3 : BREEDING SUPERIOR VARIETIES FOR CULTIVATED FODDER LEGUMES**

#### 3.1 Breeding varieties for high fodder yield and quality in cowpea

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

207 germplasm collections of forage cowpea including 184 lines derived from hybrid progenies were evaluated along with three control varieties Bundel Iobia-1 IFC-8503 and EC-4216.

Out of these, 43 were early maturing seed types and 164 were medium or late maturing fodder types. A majority of the genotypes (89) showed erect growth followed by decumbent (72) and the remaining were prostrate growth types. The plant height differed widely in the different genotypes (30-90cm). The tall and medium types were 69 and 65 in number. The peduncle length varied from 9 to 54 cm in 72
genotypes. The pod length varied from 9-24 cm with the majority of cultivars, in 12-14 cm length group. Most of the fodder types had erect growth, medium to tall plant height, long peduncle with 12-14 cm long pods.

**Initial Evaluation Trials**

Twelve promising selections including six hybrid progenies were evaluated along with three control varieties. The highest green fodder yielding varieties were HY5-P35 (37.95 t/ha) Hy8-P60-4. (36.22 t/ha) and IFC-902 (35.14 t/ha). The former two selections were derived from the cross I.L.1545 X I.L-1300 and EC 5286 X IL545, respectively.

**Initial Evaluation Trial (KBTC-1)**

Significant differences were observed in the green and dry matter yield of the varieties. The varieties IFC-9303 (39.73 t/ha) and IFC-9304 (38.89 t/ha) registered 18% and 15% and higher yield respectively, over the best control variety Bundel Lobia-1.

In dry matter IFC-9303 (6.35 t/ha) and IFC-9304 (6.97 t/ha) gave 7% and 17% higher yield than the best check Bundel Lobia-1. The varieties differed widely in characters like plant height, number of branches and leaf/stem ratio.

Amongst all the varieties IFC-9304 was highest in dry matter yield and leaf/stem ratio, second highest in green fodder yield and was therefore the best variety followed by IFC 9303.

**Advanced Varietal Trial In Cowpea (KBTC-2)**

Variety IFC-901 was the highest yielding variety, in both green (37.3 t/ha) and dry matter yield (37.3 t/ha) as against (3169 t/ha) and (5.48 t/ha) of Bundel-1 respectively.

**Seed Multiplication**

Breeder seed of recommended/released varieties and seed of elite selections contributed in coordinated trials was produced.
3.2 Strain building in lucerne
(C.B. Singh and K.S.Kohli)

Germplasm
Eighty germplasm lines including 60 collected from different parts of Maharashtra and Gujarat were sown in November 1993 in 2 rows, 3 meters long plots. In all 8 cuttings were taken. The range, mean, C. V.% and the relative distribution of cultivars in low, medium and high grades of forage yield in different cuts have been presented (Table-6). The mean yield of cultivars were relatively lower in the first two cuttings (1.59-1.66 kg/plot) as compared to other cuts (1.8-2.36 kg/plot). Only 70 cultivars consistently gave 8 cuts. Wide variations were observed in the relative distribution of cultivars in different grades of forage yield in different cuts as is evident from C.V.% values which ranged from 19-41. Amongst all the cultivars the highest yielding types in all the cuts were IL4161, IL4167, IL4119, (20-21 kg/plot).

Intra-clonal variation in elite selections
Intra-clonal phenotypic variation in 10 elite selections were studied in the first two cuttings. The size of plant population in the different selections ranged from 160-190 in the first cut and 84-96 in the second cut. Wide inter-clonal variations were observed within and between the different selections with respect to all the characters particularly the tiller number and yield of stem, leaf and whole plant. The intraclonal variation in selections L.L composite-5 and Sirsa-9 was relatively low and it was very high in IL-112,IL-440,IL-1288 for most of the characters. The plant height and tiller number ranged from 40-60 cm and 6-8 in the first cut as compared to 60-83 cm and 16-22 in the second cut. The average yield of plant (g/plant) and its leaf and stem components ranged between 46-67, 26-34, 22-34 in the first cut and 181-234, 83-119, 80-115 in the second cut. The yield character showed maximum intra-clonal diversity amongst all the characters studied.

All India Coordinated trials
During the year initial and advance varietal trials with 14 and 12 varieties were conducted. The latter trial included three IGFRI varieties namely IL-1212, IL-112 and 11-composite-93.
Table : 6 Relative frequency of Lucerne cultivars in low, medium and high grades of forage yield (kg.) per plot.

<table>
<thead>
<tr>
<th>CUT NO</th>
<th>MIN.</th>
<th>MAX.</th>
<th>MEAN.</th>
<th>S.E.</th>
<th>Frequency of cultivars</th>
<th>C.V%</th>
<th>CULTIVARS NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LOW MEDIUM HIGH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>0.2</td>
<td>2.8</td>
<td>1.59</td>
<td>0.662</td>
<td>16 51 13</td>
<td>41</td>
<td>80</td>
</tr>
<tr>
<td>2.</td>
<td>0.35</td>
<td>2.9</td>
<td>1.66</td>
<td>0.531</td>
<td>14 43 20</td>
<td>32</td>
<td>77</td>
</tr>
<tr>
<td>3.</td>
<td>1.435</td>
<td>2.26</td>
<td>2.26</td>
<td>0.652</td>
<td>3 21 53</td>
<td>27</td>
<td>77</td>
</tr>
<tr>
<td>4.</td>
<td>1.5</td>
<td>4.8</td>
<td>2.36</td>
<td>0.537</td>
<td>1 19 53</td>
<td>22</td>
<td>73</td>
</tr>
<tr>
<td>5.</td>
<td>1</td>
<td>3.5</td>
<td>1.9</td>
<td>0.561</td>
<td>5 41 26</td>
<td>29</td>
<td>72</td>
</tr>
<tr>
<td>6.</td>
<td>1</td>
<td>2.6</td>
<td>1.905</td>
<td>0.495</td>
<td>2 43 26</td>
<td>25</td>
<td>71</td>
</tr>
<tr>
<td>7.</td>
<td>0.9</td>
<td>3.55</td>
<td>1.93</td>
<td>0.613</td>
<td>3 40 27</td>
<td>31</td>
<td>70</td>
</tr>
<tr>
<td>8.</td>
<td>0.75</td>
<td>3.2</td>
<td>1.84</td>
<td>0.602</td>
<td>6 41 23</td>
<td>19</td>
<td>70</td>
</tr>
<tr>
<td>All cuts</td>
<td>7.45</td>
<td>21.95</td>
<td>15.93</td>
<td>3.01</td>
<td>3 42 25</td>
<td>19</td>
<td>70</td>
</tr>
<tr>
<td>Average</td>
<td>0.931</td>
<td>2.74</td>
<td>1.929</td>
<td>0.387</td>
<td>10 40 20</td>
<td>19</td>
<td>70</td>
</tr>
</tbody>
</table>

3.3 Genetic improvement in *Trifolium* species with special reference to Egyptian clover (D.R. Malaviya)

**Germplasm evaluation**: Nine exotic germplasm were evaluated against the check Wardan. IL 4008 and IL 40011 were marginally superior to Wardan in GM only. The lateness in the lines IL 4008, IL 40014, IL 4009 and IL 40012 was well marked. IL 40016 flowered quite early in mid January but it regenerated after cutting and survived till April end with poor vegetative growth. IL 40010 seemed to be highly cross pollinated and one year open pollinated plant showed segregation for leaf colour, branching pattern and maturity in F2. The population derived from two year open pollinated condition showed close resemblance to Mescavi type plants.

Out of five local collection from Rajasthan four possessed desirable characters for high yield. Selection of desirable plant types have been made.

**Station trial**: One station trial comprising 81 selected promising progenies revealed that CT2-34-2, S3/90 x 1x2 , S3/90 X1, S252/90-4 and CT1-25-5 are superior to the check Wardan for GM.

**Mutation breeding**: Seeds of JHB 146 were treated with EMS (1% and 0.5%) and 8 hydroxyquinoline (saturated and half saturated solution) mutants were identified. Seeds and seedlings of pentafoilate plants were treated with 0.25% colchicine. No marked change was observed in treated population however a few plants with phenotypic variation have been selected.

**Hybridization**: In F2 plant population of different crosses segregation of the character for no. of leaflets and pink flowers was noticed. Certain plant progenies in
F₃ population of BL 78 x JHB 146 outyielded the check ISB 86. Five plant progenies from a natural cross BL 78 X JHB 146 also showed better yield than check and were medium to late maturing types.

**Selections:** Further selections have been made from 840 single plant progenies including multifoliates, C₁, C₂, M₁, M₂ and M₄ generations. Some of the selections viz. Wardan mutant 38/32, Hepta op-seg 14/30-32, 36/5 T₁₀, S3/90-1 self, S42/90 penta, CT₂-48-1 self bulk-2, CT₂ 27-1-1-JB, CT₁ -51-28-SB, showed marked edge for GM on the check Wardan.

**Seed multiplication:** Seeds of varieties being tested in coordinated trials have been multiplied. Nucleus seed of JHB 89-4, proposed for identification has been produced.

Two identified varieties JHB 146 and JHB ISB-86 grown in farmers yield in Lakara village have shown good yield.

**All India Co-ordinated trial:** Two trials RBT-1 and RBT-2 were conducted. Data recorded for GM and DM showed marginal superiority of JHB 93-1 in RBT-1 and that of JHB 92-2 over the zonal as well as national check.

### 3.4 Breeding high yielding fodder varieties in lablab bean (*Lablab purpureus* L.)

(D.N. Singh)

**Advanced varietal trial:** Twelve selected strains including variety Bundel sem-1 (control) were evaluated under rainfed conditions.

**Evaluation for fodder:** Five strains namely S-27, S-2216, S-13-I, S-836 and AP-S-2 were significantly superior than the control as their GF yield was ranging between 33.2 to 30.7 t/ha as against 28.8 t/ha in the control (Table. 7).

**Evaluation for seed:** Three strains namely, AD-S-2, S-2216, and S-27 were significantly superior over the control producing 2.14 2.14 and 2.08 t/ha seed respectively as against control of 1.73 t/ha (Table. 7). Based on three years (1991 to 1993) variety S-27 is found to be the most promising one followed by S-2216 and AP-S-2. Seed yield of these three strains was higher than the control by 12.3, 7.5, and 4.6 percent.

The above mentioned five strains will be put into co-ordinated trials for fodder as well as seed.

**Germplasm evaluation:** Eighty four lines belonging to the seed species *lignosus* and *typicus* and fodder vegetable types were evaluated for a number of characters pertaining to plant, flowering, maturity, pod, seed and resistance to major
diseases, drought and frost. Two vegetable lines obtained from I. I. H. R. Bangalore were very early as they flowered within 60-65 days as against 135-170 days for most of the lines. These early lines would be utilized in the crossing programme for developing day neutral early maturing varieties for fodder/seed which are presently not available.

**VARIETAL EVALUATION IN MIXED CROPPING**

Two varieties of lablab bean viz. Bundel sem-1 and S-2216 (JLP-3) were evaluated for their growth association with maize crop. Findings reveal good symbiotic relationship between them.

**VARIETIES PERFORMANCE IN THE FARMER’S FIELDS**

During kharif, field demonstrations were carried out on two varieties of lablab bean namely, Bundel sem-1 and JLP-3 in eight farmers field of Lakara village.

**PRODUCTION OF THE NUCLEUS SEED**

Nucleus seeds of the variety Bundel sem-1 and other promising strains were produced.

**Table 7: Varieties yield potential for fodder and seed (1993-94)**

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Green fodder (t/ha) 1993-94</th>
<th>Seed yield (t/ha) 1993-94</th>
<th>Seed yield (t/ha) Average for 3 years.</th>
</tr>
</thead>
<tbody>
<tr>
<td>S.13-I</td>
<td>31.18</td>
<td>1.98</td>
<td>1.69</td>
</tr>
<tr>
<td>S-23</td>
<td>22.40</td>
<td>1.11</td>
<td>1.45</td>
</tr>
<tr>
<td>S-27</td>
<td>33.20</td>
<td>2.08</td>
<td>1.96</td>
</tr>
<tr>
<td>S-29</td>
<td>25.80</td>
<td>1.25</td>
<td>1.51</td>
</tr>
<tr>
<td>S-31</td>
<td>27.67</td>
<td>1.18</td>
<td>1.35</td>
</tr>
<tr>
<td>S-33 III</td>
<td>19.80</td>
<td>1.13</td>
<td>1.17</td>
</tr>
<tr>
<td>S-84</td>
<td>24.53</td>
<td>1.10</td>
<td>1.37</td>
</tr>
<tr>
<td>S-836</td>
<td>31.00</td>
<td>1.58</td>
<td>1.59</td>
</tr>
<tr>
<td>S-1649</td>
<td>22.20</td>
<td>1.09</td>
<td>1.26</td>
</tr>
<tr>
<td>S-2216</td>
<td>33.01</td>
<td>2.13</td>
<td>1.87</td>
</tr>
<tr>
<td>AP-S-2</td>
<td>30.73</td>
<td>2.14</td>
<td>1.82</td>
</tr>
<tr>
<td>Bundel Sem-1</td>
<td>28.80</td>
<td>1.73</td>
<td>1.74</td>
</tr>
<tr>
<td>General mean</td>
<td>27.52</td>
<td>1.54</td>
<td>1.57</td>
</tr>
<tr>
<td>CV%</td>
<td>15.7</td>
<td>21.1</td>
<td></td>
</tr>
</tbody>
</table>
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)

Selection of superior genotypes

Nine promising strains in Cenchrus ciliaris viz IGFRI 630, 632, 635, 638, 3059, 4101, 3802, 3929 8-2-3, and seven in C. setigerus viz IGFRI -29, 79, 109, 691, 698, 3931, 4056 were identified.

Twenty nine regenerates of Dichanthium, developed from anther, inflorescence, embryonal axis and node through tissue culture technique, were evaluated in the first year of growth. All the regenerates have static growth habits similar to the first year. Further, a clearcut variation in respect of growth parameters such as height (106.7-202.3 cm), leaf number/tiller (11-23), tiller no./plant (72.3-156.0), GFY (6.35-19.37 t/ha), leaf/stem ratio (10.17-0.67) and growth habit erect to prostrate. Eleven progenies were identified as promising for different attributes.

Evaluation of promising selections

Eight promising selections of Cenchrus ciliaris along with IGFRI -3108 as check, were evaluated in second year of growth. The data are presented in table-8.

Eight promising selections of marvel grass along with check (marvel-8), planted in kharif 1991, were evaluated in the third year of growth. The data are presented in table-9.

Coordinated trial

Nine entries of Dichanthum were evaluated in the first year of growth. Five entries viz. IGFRI-2225, 1989, 5851, 1978 and 1994 were found superior for green forage yield and three entries viz. IGFRI-1981, 585-1 and 2225 for dry matter yield over the general mean.

Seed multiplication

The seeds of released/prereleased varieties along with other promising selections were multiplied.
Table 8: Average performance of C. ciliaris strains for different characters.

<table>
<thead>
<tr>
<th>Plant height (cm)</th>
<th>Leaf no.</th>
<th>Leaf length (cm)</th>
<th>Leaf width (cm)</th>
<th>Tiller no.</th>
<th>GFY (t/ha)</th>
<th>DMY (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 3105</td>
<td>105.8</td>
<td>14.6</td>
<td>35.7</td>
<td>0.74</td>
<td>98.5</td>
<td>11.90</td>
</tr>
<tr>
<td>2. 3133</td>
<td>107.3</td>
<td>12.6</td>
<td>29.9</td>
<td>0.75</td>
<td>86.7</td>
<td>14.92</td>
</tr>
<tr>
<td>3. 3113</td>
<td>107.0</td>
<td>13.0</td>
<td>32.3</td>
<td>0.79</td>
<td>46.5</td>
<td>8.41</td>
</tr>
<tr>
<td>4. 84-3</td>
<td>103.3</td>
<td>14.1</td>
<td>30.3</td>
<td>0.82</td>
<td>67.5</td>
<td>9.37</td>
</tr>
<tr>
<td>5. 84-10</td>
<td>109.5</td>
<td>12.3</td>
<td>31.0</td>
<td>0.79</td>
<td>106.6</td>
<td>17.14</td>
</tr>
<tr>
<td>6. 72-1</td>
<td>105.1</td>
<td>11.7</td>
<td>33.9</td>
<td>0.72</td>
<td>90.0</td>
<td>11.11</td>
</tr>
<tr>
<td>7. 673</td>
<td>94.5</td>
<td>11.5</td>
<td>30.5</td>
<td>0.82</td>
<td>34.2</td>
<td>8.09</td>
</tr>
<tr>
<td>8. 675</td>
<td>99.8</td>
<td>14.2</td>
<td>33.5</td>
<td>0.72</td>
<td>113.0</td>
<td>16.19</td>
</tr>
<tr>
<td>9. 3108</td>
<td>113.2</td>
<td>12.7</td>
<td>30.9</td>
<td>0.82</td>
<td>84.2</td>
<td>14.29</td>
</tr>
</tbody>
</table>

Mean: 12.38 3.78
CV: 10.04 14.48

Table 9: Performance of promising strains of Dichanthium

<table>
<thead>
<tr>
<th>Strains</th>
<th>Plant height (cm)</th>
<th>Leaf No.</th>
<th>Leaf length (cm)</th>
<th>Leaf width (cm)</th>
<th>Tiller/ plant</th>
<th>GFY (t/ha)</th>
<th>DMY (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGFRI</td>
<td>2230</td>
<td>12.7</td>
<td>35.3</td>
<td>0.77</td>
<td>93.7</td>
<td>17.33</td>
<td>5.99</td>
</tr>
<tr>
<td></td>
<td>2173</td>
<td>13.5</td>
<td>36.8</td>
<td>0.90</td>
<td>76.2</td>
<td>16.65</td>
<td>5.65</td>
</tr>
<tr>
<td></td>
<td>2172</td>
<td>12.5</td>
<td>37.2</td>
<td>0.87</td>
<td>105.2</td>
<td>20.63</td>
<td>6.54</td>
</tr>
<tr>
<td></td>
<td>1985</td>
<td>12.9</td>
<td>28.5</td>
<td>0.75</td>
<td>105.5</td>
<td>17.87</td>
<td>5.81</td>
</tr>
<tr>
<td></td>
<td>497</td>
<td>13.0</td>
<td>30.3</td>
<td>0.97</td>
<td>110.3</td>
<td>19.05</td>
<td>7.46</td>
</tr>
<tr>
<td></td>
<td>844</td>
<td>12.7</td>
<td>28.3</td>
<td>0.74</td>
<td>131.5</td>
<td>14.68</td>
<td>5.71</td>
</tr>
<tr>
<td></td>
<td>2958</td>
<td>13.5</td>
<td>26.1</td>
<td>0.75</td>
<td>136.7</td>
<td>12.30</td>
<td>5.03</td>
</tr>
<tr>
<td>Mar-8</td>
<td>115.1</td>
<td>14.1</td>
<td>27.1</td>
<td>0.81</td>
<td>132.1</td>
<td>15.48</td>
<td>5.91</td>
</tr>
</tbody>
</table>

Mean: 16.92 6.03
CV%: 8.39 10.8

PI-5: CYTOGENETIC STUDIES IN FORAGE AND PASTURE SPECIES

5.1 Cytogenetical studies in cultivated legumes

(S.N. Tripathi)

Mitotic studies in Medicago species.

The annual medics (M. orbicularis, M. rotata and M. coronata) were diploid (2n = 2x = 16) and perennial Medicago species (M. sativa var. Anand 4) species was tetraploid (2n = 4x = 32). Shortest chromosome in annual Medicago species is less than 2.00 μm; whereas in perennial Medicago sativa it is greater than 2.00 μm. The annual medics as compared to perennial species have shown pronounced differences between lengths of shortest and longest chromosomes in the complement. The chromosomes are more asymmetrical in annual medics than the
perennial species. This indicates that these annual are of late evolutionary origin than the perennial *Medicago* sativa.

**Meiotic studies in induced tetraploids of *Medicago rotata* and *M. orbicularis***.

The preponderance of bivalents was noticed in the PMCs of both the colchicine induced tetraploids of *M. rotata* and *M. orbicularis*. The frequency of bivalents in tetraploid *M. rotata* was 66.5% followed by quadrivalent (26.5%) . In contrast, the frequency of trivalent and univalent was much lower i.e. 2.3 and 4.5 % respectively. In *M. orbicularis*, the percentage of bivalents was 61.5, quadrivaleut (33.25 %), trivalent (3.00%) and univalent (2.5%).

In both the species, the highest number of quadrivalents per PMC was found to be 5. In *M. orbicularis* 54% PMCs exhibited 3-5 quadrivalents. Whereas in *M. rotata* 40% of PMCs showed 3-5 quadrivalents.

The trivalents and/or univalents probably are the result of either disjointed quadrivalents or due to precocious division of bivalent(s).

Presence of laggards at anaphase I was quite common in both the species, and is probably the manifestation of non disjunction or disturbances in the chiasmata terminalization process.

While investigating the meiotic stages, PMCs with a synchronus chromosome divergence were also noticed i.e., at one pole chromosome were entering anaphase II but at the other pole, this process had not been started and chromosome were at metaphase II. The other abnormalities observed were presence of "polyad" pollen and cytombixis.

The anomalies in the chromosomal behaviour during meiosis are primarily responsible for the formation of unbalanced gametes and hence in the reduction of fertility in these colchicine induced tetraploids of *Medicago* species.

**5.2 Cytogenetical studies in range legumes**

(S. N. Zadoo)

Cytological studies on 19 accession including 13 species of genus *Sesbania* revealed that the species had a symmetrical karyotype, falling in 3v + 3L type.
Meiotic studies indicate no variation between different accessions of same species, in traits like number of open/ close bivalents and frequency per cell. All the species are compulsive inbreeders. The diploid accessions show regular formation of 6 bivalents, as the tetraploids show perfect diploidised behaviour and occurrence of 12 bivalents. Attempts of interspecific hybridisation between S. speciosa, S. oculeata and S. macrocarpa did not yield any seed.

*Sesbania speciosa*, *S. punctata*, *S. species I. L 4025* and *S. restrata* were treated with aqueous solution of colchicine to induce tetraploidy. Out of these only *S. speciosa* responded positively, as revealed by pollen grain size and stainability. Seed set was very poor and only a few shrivelled seeds could be collected.

5.3 Genetic manipulation of forage crop species through tissue culture studies

(M.G. Gupta and Sanjeev Gupta)

Callus induction and regeneration of plants and their subsequent establishment in the field condition were successfully attempted in *Cenchrus*, *Pennisetum*, *Chrysopogon* and *Panicum maximum* through various culture (agar/solid) media and also in suspension cultures using different sources of tissues/organs, namely, young leaf base, nodal segments, immature inflorescence embryonal axis etc. Callus induction was best on MS medium containing 2,4-D (2.0-5.0 ppm) in all the grasses. The compact and ash coloured calli regenerated in medium containing BPA (0.5 ppm) and IAA (2.0-5.0 ppm). Regeneration of somatic embryos and (2.0-5.0 ppm). Regeneration of somatic embryos and bud organogenesis took place within 12-15 days followed by rhizogenesis in BAP (0.5 ppm) and NAA (5.00ppm).

Studies on callus induction and regeneration of forage legumes were conducted using seeds, hypocotyl, epicotyl, cotyledons, young leaves and nodes as explant on various culture media viz; B5, Blaydes, MA and SH supplemented with BAP (0.0-0.2 ppm) and 2.4-D (1.0-5.0 ppm). Callus induction was quick and profuse on media containing only 2.4-D(4.0-5.0 ppm) in both *Medicago* and *Trifolium* using cotyledonary regions as explant. In *Medicago* direct shoot bud organogenesis was observed in some cultures from hypertrophied and semi-differentiated cotyledonary
segments in BAP (0.2 ppm) and 2,4-D (2.0 ppm) Nodular and friable calli and organogenic segments were optimally redifferentiated in 15-20 days on MS medium containing 1.0 ppm BAP and 5.0 ppm IAA. There was poor response of in vitro regeneration of *Trifolium* from callus as rhizogenesis was difficult.

The cytogenetic investigation under microscope revealed no variation in chromosome number from individual to individual among the regenerates of grasses.

5.4 Cytogenetical approach to berseem improvement

(A.K. Roy)

**Polyploidy Induction in *Trifolium alexandrinum***

Tetraploid progenies in C$_3$ and C$_2$ generations were screened and selections were done on the basis of morphological characters. Morphologically tetraploids can be differentiated from their diploid counterparts on the basis of thick, hairy broad and long leaves with characteristic serrate margins and thick stems. Tetraploids also have bigger stomata and less stomatal frequency per unit area. Detailed morphological and anatomical data were recorded in 11 different strains of induced tetraploids and their diploid counterparts. Tetraploid status was confirmed by cytological observations viz. pollen size, pollen stainability, nucleolar frequency and meiotic chromosomal configurations. In a few selected lines very less frequency of quadrivalent formations were recorded. These lines were also high seed producers as compared to other tetraploid strains. Data on root nodule, fresh and dry weight were also recorded.

**Polyploidy Induction in *T. resupinatum***

Selections were made on the basis of morphological observations in C$_1$ generation to get autotetraploid lines.
DIVISION OF AGRONOMY

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

3.3 Cropping patterns for maximum forage production

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

(S.N. Tripathi)

Among the renovation techniques, maximum green forage yield of 60.2 t/ha
(15.2 t DM/ha) was recorded by the stubble shaving treatment followed by untreated
control (55.8 t GM and 13.4 t DM/ha) and stubble burning (53.4 t GM and 13.0 t
DM/ha). Application of half of the total N (200 kg/ha) through urea and half as FYM
gave the highest forage yield (60.1 t GM and 14.9 t DM/ha) followed by use of 75% N
through FYM and 25% as urea (55.5 t GM and 13.5 t DM/ha) and application of full
do se of N through urea (53.8 t GM and 13.5 t DM/ha). The later two treatments were
statistically at par. Forage yield of guinea was highest (58 t GM and 14.6 t/OM/ha with
close inter row spacing of 50 cm and least with wider spacing of 100 cm (55 t GM and
13.3 t DM/ha).

The intercrop of berseem gave significantly higher yield in stubble burning
treatment (92.2 t GM and 14.0 t DM/ha) followed by stubble shaving (83.4 t GM and
13.3 t DM/ha) and control (79.2 t GM and 12.9 t DM/ha).

Application of 50 to 75% of N to guinea grass through FYM had positive effect
on the forage yield of the following intercrop of berseem recording 86.2 to 86.7 t
GM/ha (13.5 to 13.7 t DM) as compared to the forage yield of 82.0 t/ha (13.1 t DM)
obtained in the treatments, where N of guinea was supplied through urea alone.
Forage yield of berseem was higher in wider spacing (75 to 100 cm) of guinea grass
(85.5 to 86.2 t GM and 13.6 to 13.7 t DM/ha) as compared to narrow spacing of 50 cm
(82.8 t GM 12.9 t DM/ha ). Considering the yields of both guinea grass and berseem,
maximum dry matter yield of 28.5 t/ha (143.6 t/ha green fodder) was recorded by
stubble shaving treatment.
3.4 Intercropping of Dolichos in grain sorghum with different fertilizer schedules under dryland conditions

Significantly higher grain and stover yields of sorghum were obtained with pure crop of sorghum receiving 60kg N + 40 kg P₂O₅/ha followed by intercropped with Dolichos and cowpea at same fertilizer schedule. In intercropping system, significant increase in grain and stover yields of sorghum with Dolichos at 60kg N + 40 kg P₂O₅/ha were at par with 40 kg + 20 kg P₂O₅/ha than the other intercropping system.

Significantly higher green fodder yield was obtained in pure crop of Dolichos with 20kg N + 40 kg P₂O₅/ha as compared to sorghum + Dolichos intercropping systems. It was also noticed that significantly higher green fodder yield (13.2 t/ha) was obtained in sorghum + Dolichos with 60 kg N + 40 kg P₂O₅/ha than sorghum + cowpea at same fertilizer level. The Dolichos as an intercrop maintained similar level of green forage productivity with 60 kg N + 20 kg P₂O₅/ha (13 t/ha) without much reduction in grain yield of sorghum, indicating saving of 20 kg P₂O₅/ha as compared to cowpea intercrop.

On equivalence basis the productivity of grain sorghum + Dolichos at 60 kg N + 20 kg P₂O₅/ha (3.62 t/ha) and 60 kg N + 20 kg P₂O₅/ha (3.68 t/ha) was at par and significantly higher than pure crop of sorghum and Dolichos.

Thus, intercropping of grain sorghum (CSH 5) with Dolichos (JLP4) not only maintained higher grain and stover yields of sorghum but also provided bonus yield of fodder (13.0 t/ha) along with saving of 20 kg P₂O₅/ha under dryland conditions of Bundel Khand region.

3.6 Sugarcane based cropping systems involving parallel fodder crops

(B. S. Sinsinwar)

During the year 1992-93, total yield of only oat could be taken, whereas berseem continued up to April, 1993 giving 5 cuttings and lucerne continued up to June, 1993 giving seven cuttings. Total green fodder yield of 51.8, 46.6 and 13.7 t/ha was received from berseem, lucerne and oat, respectively. The respective dry matter and crude protein yields were 10.9, 13.1 and 3.01 t/ha and 218, 262 and 60 kg/ha, respectively. Due to early (6.11.1993) harvesting the sucrose percentage ranged from 12-14.7% and Brix value ranged from 12 to 20% which were low and non significant. Sugarcane yield was highest in sole crop treatment (129.5 t/ha) followed
by intercropped with oat (127.2 t/ha). The lowest cane yield was recorded in the plots intercropped with lucerne. Sugarcane top yield was also highest in sole crop (57.2 t/ha) followed by intercropped with oat (55.8 t/ha). The lowest yield was recorded in the plots intercropped with lucerne. There was no effect of nitrogen levels on sugarcane as well as fodder crops.

**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)

**Effect of sowing methods and crop density on the productivity and longevity of berseem + lucerne mixture**

Total of five cuttings were obtained in the crop season. Significantly highest green forage (67.8 t/ha) yield was obtained from line sown lucerne + berseem broadcast on muddy seed bed the same day as compared to sowing of berseem 15 days later (62.0 t/ha). However, the dry matter yields of 13.8 and 13.3 t/ha with these treatments were statistically at par.

The green forage production of pure berseem (76.7 t/ha) was at par with mixtures comprising 2/3 berseem + 1/3 lucerne (73.8 t/ha) and full seed rate of both the components (71.9 t/ha) but was statistically higher than 1/2 berseem + 1/2 lucerne (68.1 t/ha) and 1/3 berseem + 2/3 lucerne (64.7 t/ha). Moreover, all the mixed stands significantly out yielded pure lucerne (33.9 t/ha) in green matter production. The dry matter production was significantly highest 15.1 t/ha with full seed rate of both the crops as compared to pure lucerne (9.5 t/ha) and 1/3 berseem + 2/3 lucerne (13.2 t/ha). The other seed proportions were at par with pure berseem in dry matter accumulation. Thus, taking into account both green matter production and dry matter accumulation, sowing of 2/3 berseem + 1/3 lucerne holds promise. Lucerne may be sown in lines and berseem broadcasted in muddy field on the same day for sustained forage production.

**Evaluation of oat varieties under differential moisture stress conditions**

Oat variety JHO-881 produced significantly highest green forage (44.9 t/ha) and dry matter (13.1 t/ha) yields over other varieties. Green forage yield of JHO-883 (37 t/ha) was significantly higher than that of JHO-865 (31.6 t/ha). In terms of dry
matter yield, however, JHO-865 was superior (11.4 t/ha) to JHO - 883 (10.2 t/ha). The dry weight of roots in top 0-15 cm layer was highest in case of JHO-865 (31.9 g/9375 cm$^3$) followed by JHO-883 (29.7 g/9375 cm$^3$). Likewise, the highest water use efficiency (87.3 kg dm/ha/mm) was also obtained with JHO-881 followed by JHO-865 (76 kg dm/ha/mm).

The highest green forage (46.5 t/ha) yield was obtained with 4 irrigations scheduled at crown root initiation (CRI), tillering, jointing and flower initiation stages which was significantly superior to 2 irrigations but at par with 3 irrigations. Among different schedules of 3 irrigation, missing irrigation at initiation of flowering caused greatest reduction in green forage yield. On the other hand, missing irrigation at tillering substantially reduced the dry matter accumulation, significantly highest dry matter production occurred with 3 irrigations (13.6 t/ha) scheduled at CRI, tillering and flower initiation stages as compared to 2 irrigations at tillering and flower initiation. The dry weight of roots was highest (36.2 g/9375 cm$^3$) with 2 irrigations at CRI and jointing stages. The irrigation water use efficiency decreased with increasing number of irrigations. However among the group of 3, irrigation scheduling at CRI, tillering and flower initiation resulted in maximum water use efficiency of 75.6 kg dm/ha/mm.

Variety JHO-881 receiving 4 irrigations resulted in significantly highest green forage production of 59.3 t/ha. Variety JHO-881 also produced significantly highest green forage with 3 irrigations (51.5 t/ha) scheduled at CRI, tillering and flower initiation stages. Therefore, variety JHO-881 with 4 irrigation phytopshased at CRI, tillering, jointing and flower initiation stages holds promise for higher forage yield. If 3 irrigations are available jointing stage may be overlooked.

4.2 Soil, water and crop management practices for seasonally water logged soils/areas

(N. P. Shukla and Menhi Lal)

Alley cropping of Sesbania with forage grasses (Operational Research Project)

Under such soil conditions, 65% plants of $S. \, sesban$ survived and produced 4.4 t green and 1.3 t dry fodder/ha through loppings at 75 cm height. Para grass in alley spaces produces green fodder of 33.5 t/ha and dry matter of 6.7 t/ha.
These observations, therefore, indicate that *S. sesban* is quite tolerant to waterlogged conditions and offers good scope as alley species with interplanted *B. mutica* (Para grass) under such conditions.

### 4.3 Evaluation of different irrigation methods and soil management techniques for efficient water use

(N. P. Shukla and Menhi Lal)

**Evaluation of existing irrigation methods on farmers' field in watershed areas (Case study)**

Under this programme, the work on constraints analysis continued in Lakara (9 farmers), Rund Karari (8 farmers) and Karari (8 farmers) covered under the watershed project.

In Lakara on an average the ground water fall from September to December was 2.41 meter and from December to March 0.87 m. All the dug wells were in the bunded area. Out of nine farmers, six had grown groundnut and needed irrigation at the time of digging for better recovery during October and November. During *kharif*, the recharge of the dug well was quite rapid and water was available for supplemental irrigation as and when required. During *rabi* season all the farmers had grown wheat. Berseem was grown by three farmers on one acre each. Vegetables were grown by four farmers each on one acre land. Gram + mustard was grown by three farmers.

Thus, most of the irrigation resources were diverted to wheat, berseem and vegetable crops. The crops like mustard and gram required only two irrigations.

In village Rund Karari, 4 farmers belonged to treated watershed and 4 to nontreated areas. The average ground water fall from September to December was 3.61 m in bunded area and 5.20 m in nonbunded area. From December to March, the average drop in water table was 1.81 m in bunded portion of watershed whereas no definite trend could be observed in the unbunded area. During *kharif*, all the four farmers in bunded area had grown groundnut. In non-bunded area only farmer raised groundnut and that too on one acre only. During *rabi* all the eight farmers had grown wheat but two farmers with limited water resources could provide only two irrigations and the crop suffered due to lack of proper irrigation. Four farmers had also grown berseem on 1/2 acre each. Mustard was grown by two farmers without irrigation near pond after water has receded. Three farmers had grown gram providing two irrigations.
In Karari village, eight wells were selected for study in non-bunded area. On an average, the ground water fall from September to December was 2.59 m and from December to March 2.48 m. During *kharif* season, three farmers cultivated groundnut and one had grown jowar. During *rabi*, all the farmers cultivated wheat and berseem. Mustard was grown by four farmers. Irrigation to wheat was inadequate. On the other hand, due to small area under berseem, 8-10 irrigations, were provided to have frequent cuttings and good yield.

Thus, in Lakara village where the soil is kabar and parwa type, bunding caused rapid recharge of wells ensuring water supply for irrigation and as such occupied major areas under irrigation. In Rund Karari by and large the soil is rakar with low moisture retentivity. Moreover the area is not fully bunded and therefore, the wells are not adequately recharged. Groundnut in Kharif and wheat in Rabi are the principal crops of the village. However, large chunk remain uncultivated due to lack of irrigation water. There is scope for extensive irrigation with low water requiring crops like gram, barley and mustard in this village.

**AG - 5 : AMELIORATION OF PROBLEM SOILS/AREAS FOR FORAGE PRODUCTON**

5.1 Rehabilitation of salt-affected soils at Daleepnagar (Kanpur)

(In collaboration with CSAUA & T, Kanpur)

5.1.1 Performance of grasses on salt-affected soils in sole stand

(Banwari Lal, R.L. Arya, A. Singh, R.B. Yadava and S.P. Singh)

The experiment was conducted on salt-affected soils at Daleepnagar, Kanpur having pH, 9.5, ESP 40 and EC 0.99 ds/m. Three cuttings of grasses were taken in the month of July and September, 1993. Significantly higher green fodder (73.0 t/ha) and dry matter (18.33 t/ha) yield were obtained in kallar grass (*Leptochloa fusca*) as compared to para grass (68.98 t/ha green fodder and 17.88 t/ha dry matter) nandi grass (*Setaria sphacelata*) (42.49 t/ha green fodder and 11.47 t/ha dry matter). Application of pyrite 1.6 t/ha produced significantly higher green fodder (66.85 t/ha) and dry matter (16.98 t/ha) than without soil amendments (57.63 t green fodder and 15.45 dry matter yields t/ha). Application of FYM 5.0 t/ha also produced
significantly higher green fodder (59.98 t/ha) and dry matter (15.74 t/ha) yield than the control treatment.

5.1.2 Development of suitable agro-silvipasture systems for salt-affected soils

(Banwari Lal, R.L. Arya, A. Singh, R.B. Yadava and S.P. Singh)

The field experiment was initiated on highly sodic soils having pH 10.2-10.5, ESP 81 and EC 7.0 ds/m.

Kallar grass performed well on sodic soils in interrow spaces of shisham plantation and produced highest green forage (23.0 t/ha) and dry matter (7.36 t/ha) yield with pyrite @ 5.0 t/ha in two cuts (Table 10). The other grasses produced green fodder and dry matter yield as paragrass (18.2 and 5.65 t/ha), rhodes grass (16.7 and 5.34 t/ha) and nandi grass (13.5 and 4.05 t/ha), with pyrite applications, respectively. The minimum fodder yield were obtained in all grasses under control (without soil amendments).

The tree species *Prosopis juliflora* performed well with survival rate of 89% followed by *Dalbergia sisoo* (85%) , *Albizia amara* (80%) and *Leucaena leucocephala* (70%). The highest plant height (219 cm) was recorded with *Prosopis juliflora* followed by *Leucaena leucocephala* (203 cm), Eucalyptus hybrid (195 cm), *Dalbergia sisoo* (175 cm), *Azadirachta indica* (155 cm), *Albizia amara* (123 cm), *Albizia lebbek* (112 cm), *Syzyzium cumini* (111 cm) and *Terminalia arjuna* (105 cm).

The collar girth was recorded higher (7.2 cm) in *Prosopis juliflora* followed by *Dalbergia sisoo* (5.4 cm), *Terminalia arjuna* (5.3 cm), *Eucalyptus hybrid* (5.1 cm), *Albizia lebbek* (5.1 cm) and *Albizia amara* (4.3 cm).

5.2 Forage production in waterlogged areas at crop research station Ghagharaghat

(Banwari Lal, R.L. Arya, A.Singh, R.B. Yadava, O.P. Singh and G. Singh)

1. Performance of grasses under two sources of nitrogen in flush flood conditions

Significantly higher green fodder (86.28 t/ha) yield were obtained in *Setaria sphacelata* (nandi grass) as compared to *Leptochloa fusca* (Karnal grass) (12.18 t
green fodder /ha). *Brachiaria mutica* produced significantly higher green forage (81.77 t/ha) yield than the Karnal grass. Application of 50% of nitrogen through urea and 50% through FYM produced significantly higher green fodder (67.83 t/ha) yield as compared to 100%N through urea (52.33 t green fodder /ha):

The organic carbon content, availability of N, P and K in soil and chemical composition of grass (N,P,K, Ca and Mg) were more where FYM was added to supplement 50% requirement of fertilizer nitrogen. The organic carbon content (0.33%), available N(274.4kg/ha), available P(16.33 kg/ha) and available K(140.0 kg/ha) in soil and chemical composition of grasses (N,P,K, Ca and Mg) were higher in *Setaria sphacelata* than *Brachiaria mutica*.

2. Forage production on differential water stagnation conditions

The highest green forage (102.56 t/ha) yields obtained in *Brachiaria mutica* followed by *Setaria sphacelata* (80.54 t green forage /ha and 26.40 t dry matter /ha) and Napier bajra hybrid-6 (30.49 t green forage and 19.11 t dry matter /ha). The minimum green forage (14.37 t/ha and dry matter 5.99 t/ha) yield was obtained in *Leptochloa fusca*. Highest total green forage (99.35 t/ha) yield was obtained in 50-100 cm depth of water logging (deep) followed by shallow depth of water logging (upto 50 cm). Minimum green forage (14.69 t/ha) yield was obtained in deep water logging (> 100cm) conditions.

The analysis of surface (0-15 cm) soil samples reveled that organic Carbon content was more under shallow depth as compared to medium depth of water logging. However, reverse trend was noticed with respect to available N, P and K.

The nutrient content of Ca, Mg & K in plants decreased with increasing depth of waterlogging. However, no specific trend was observed for N and P contents.

3. Crop diversification trials: Alternative to deep water rice consorium

(Banwari Lal, Panjab Singh, V.P. Singh, O.P. Singh and R.L. Arya)

The productivity of crop diversification trial in alternative to deep water rice consorium was carried out at crop research station, Ghagharghat. A field study consisting of 8 treatment combinations of different food, commercial and forage crops viz; sugarcane - ratoon, rice-sunflower-maize + cowpea, rice-linseed-maize + cowpea, rice-lentil-maize + cowpea, rice-wheat-Maize + cowpea, rice-mustard-Maize + cowpea, paragrasses + berseem and banana - banana was evaluated in
randomized block design. Highest rice equivalent yield (21.891 t/ha) was obtained in sugarcane- ratoon cropping sequence followed by banana- banana and rice- wheat -maize + cowpea cropping sequence. The highest net return was also obtained in sugarcane- ratoon (Rs.38912 /ha) followed by banana -banana (Rs. 33903/ha). However, highest benefit/cost ratio (3.99) was obtained in rice -mustard -maize + cowpea sequence.
DIVISION OF GRASSLAND MANAGEMENT

GM-3 : EVALUATION OF PRESCRIBED BURNING AS A RANGE MANAGEMENT TOOL

(J.N.Gupta)

Two experiments were laid out during 1992-93 to evaluate burning tolerance of pasture species and analysis impact of time and frequency of burning on natural Sema-Heteropogon grassland reseeded with range legumes. In the first experiment, eight grasses (Bothriochloa intermedia, Chrysopogon fulvus, Dichanthium annulatum, Panicum antidotale, Panicum maximum, Pennisetum pedicellatum (Perennial), P. polystachyon and trispecific hybrid of Pennisetum) and four legumes (Arachis hagenbeckii, Clitoria ternatea, Macroptelium atropurpureum and Stylosanthes scabra) were established in separate plots. The second experiment was in natural grassland wherein range legumes were reseeded. As per schedule first burning was imposed during January 1994. Before burning the vegetation was harvested in November 93 and plant population and biomass were recorded. Observations on regrowth were recorded 40 days after burning (Table 11). No mortality was noticed in any species. High intensity of fire was observed to be detrimental to pedicellatum, P. polystachyon and D. annulatum whereas low intensity of fire or light burning was found beneficial to all these species.

In case of legumes positive increase in regenerated biomass was observed only in A. hagenbeckii and atropurpureum. Twenty percent mortality was observed in ternatea due to burning.

Table : 11 Regenerated biomass at 40 days after winter burning.
(dry weight g/m$^2$)

<table>
<thead>
<tr>
<th>Vegetation</th>
<th>Winter Burning</th>
<th>Control</th>
<th>Difference</th>
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</thead>
<tbody>
<tr>
<td>Natural Grassland</td>
<td>8.6*</td>
<td>6.1</td>
<td>+2.5</td>
</tr>
<tr>
<td>Grasses:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bothriochloa intermedia</td>
<td>5.9</td>
<td>2.8</td>
<td>+3.1</td>
</tr>
<tr>
<td>Chrysopogon fulvus</td>
<td>8.9</td>
<td>5.0</td>
<td>+3.9</td>
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<tr>
<td>Dichanthium annulatum</td>
<td>4.0</td>
<td>2.9</td>
<td>+1.1</td>
</tr>
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<td>Panicum antidotale</td>
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<td>2.1</td>
<td>+7.6</td>
</tr>
<tr>
<td>Panicum maximum</td>
<td>3.7</td>
<td>2.6</td>
<td>+1.2</td>
</tr>
<tr>
<td>Pennisetum pedicellatum (Perennial)</td>
<td>8.9</td>
<td>6.6</td>
<td>+2.3</td>
</tr>
<tr>
<td>Panicum polystachyon</td>
<td>7.5</td>
<td>6.7</td>
<td>+0.8</td>
</tr>
<tr>
<td>Pennisetum (trispecific hybrid)</td>
<td>14.3</td>
<td>23.5</td>
<td>-9.2</td>
</tr>
<tr>
<td>Legumes:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arachis hagenbeckii</td>
<td>7.5</td>
<td>3.1</td>
<td>+4.4</td>
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<td>Clitoria ternatea</td>
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<td>Stylosanthes scabra</td>
<td>10.4</td>
<td>13.2</td>
<td>-2.8</td>
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</tbody>
</table>

*Average from eight quadrats
GM-4 : STUDIES ON ALLELOPATHIC POTENTIAL OF RANGE GRASSES, LEGUMES AND FORAGES IN A GRASSLAND ECOSYSTEM

(S.S. Parihar)

1. Effect of grass residue on nodulation and legume development

A pot bioassay experiment was conducted using grass residue (root and shoot powder 1:1) @ 2.5 g per kg of soil. The root and shoot powder of *Cenchrus setigerus* and *Chrysopogon fulvus* were mixed with soil in pots and seeds of range legumes were sown in the first week of September 1993. The pots were irrigated with a uniform quantity of water at regular intervals and were allowed to leach freely. Observations on growth legume were taken after 45 days of growth. Studies revealed that root and shoot residues of the two grasses had no significant effect on legume growth as compared to control although, aqueous extract of the two grasses had inhibitory effect on number of nodules and root and shoot growth as observed in the previous year.

GM 5.1 : GRAZING PREFERENCES OF CAFETERIA SPECIES

(J.P. Singh and Vinod Shankar)

Grazing by sheep started in August 1993, which continued up to February 1994. During this period 7 out of 12 sheep gave birth to lambs which also grazed along with the sheep. Daily movement along with grazing time spent in each grass/legume stand and body weight at monthly intervals were recorded. Pasture measurements recorded were plant population, plant height, total and effective tillers/branches, basal cover, foliage cover, biomass, leaf : stem ratio and weed population. Grazing preferences during monsoon, post monsoon, winter and spring were studied. Percentage time spent in various blocks having different species was also studied. The observations recorded have been presented in fig 1-4.

GM-6 : EVALUATION OF UNDER-EXPLOITED AND UNDER-UTILIZED PLANTS FOR RANGELANDS

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

Under-utilized species viz, *Atriplex*, *Canavalia*, *Arachis*, *Ipomea*, *Boerhaavia* and *Simaraua glauca* were grown in field for their evaluation. Some under-utilized
Fig. 1: Percentage of time spent by sheep in grass, legume and annual weeds from August to February.

Fig. 2: Percentage of time spent by sheep in grazing and resting period.
forage species viz, *Ipomoea aquatica*, *Polygonum* species and one strain of *Arachis* sp were found suitable for wetlands.

**Atriplex species**: Eight accessions of different species of *Atriplex* viz, *A. amnicola*, *A. halimus*, *A. canescens*, *A. spongiosa*, *A. lentiformis* and one unidentified *Atriplex* collection were received from Project Coordinator. Under-utilized and Under-exploited crops. Out of these accessions seeds of *A. halimus* and the unidentified *Atriplex* sp. (ex Hissar) did not germinate. Seedlings of the rest of the *Atriplex* species have been transferred to polypots in the nursery. Out of the three species viz, *A. nummularia*, *A. amnicola* and *A. canescens* planted previous year, *A. canescens* did not survive. Growth performance of remaining two species have been recorded (Table 12). In both the species leaf size was drastically reduced as compared to 90 days growth of last year, whereas a considerable increase was noticed in plant height, branch number, canopy cover and basal cover. Similar pattern of growth was observed in the saline habitat of the Daleep Nagar Farm of the CSUAT, Kanpur.

**Fig. 3: Number of visits of sheep in grass, legume and annual weeds**

![Graph showing the number of visits of sheep in grass, legume and annual weeds from August to February.](image-url)
Fig. 4: Reduction (%) in plant population (Na/ha) of pasture legumes.
Dry matter production and response to grazing in *Arachis* sp

Two rhizomatous species viz., *A. glabrata* and *A. hagenbeckii* gave 2.9 and 3.3 Mg DM/ha/year, respectively on irrigated sandy loam soil. Dry forage under rainfed condition was low viz, 1.7 and 2.1 Mg/DM/ha/year in *A. glabrata* and *A. hagenbeckii*, respectively. Both these species along with other ten legumes were also evaluated under grazing by cattle and sheep. A decreasing trend in plant population was observed in all the legumes except *Arachis* species. Both *Arachis* species were grazed during the lean period i.e., November onwards.

Table 12 Performance of *Atriplex* species (average from 5 plants of 15 months growth)

<table>
<thead>
<tr>
<th>Characters</th>
<th><em>A. nummularia</em> Normal soil (Jhansi)</th>
<th><em>A. nummularia</em> Saline soil (Kanpur)</th>
<th><em>A. amnicola</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant height (cm)</td>
<td>124.2</td>
<td>128.3</td>
<td>63.0</td>
</tr>
<tr>
<td>No of branches</td>
<td>9.0</td>
<td>11.2</td>
<td>25.0</td>
</tr>
<tr>
<td>Length of longest branch (cm)</td>
<td>124.2</td>
<td>128.3</td>
<td>72.6</td>
</tr>
<tr>
<td>No. of nodes on longest branch</td>
<td>50.6</td>
<td>56.5</td>
<td>42.1</td>
</tr>
<tr>
<td>Basal cover cm²</td>
<td>56.7</td>
<td>-</td>
<td>84.9</td>
</tr>
<tr>
<td>Foliage cover m²</td>
<td>0.34</td>
<td>-</td>
<td>0.36</td>
</tr>
<tr>
<td>Leaf Length (cm)</td>
<td>2.9</td>
<td>3.1</td>
<td>2.8</td>
</tr>
<tr>
<td>Leaf breadth (cm)</td>
<td>1.9</td>
<td>2.2</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Table 13. Potentials of rhizomatous *Arachis* species

<table>
<thead>
<tr>
<th>Parameter/Species</th>
<th><em>A. glabrata</em></th>
<th><em>A. hasgenbeckii</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. DM production /annum from sandy loam soil under irrigation (t/ha)</td>
<td>2.9</td>
<td>3.3</td>
</tr>
<tr>
<td>2. DM production under rainfed condition (t/ha)</td>
<td>1.7</td>
<td>2.1</td>
</tr>
<tr>
<td>(i) sandy loam soils</td>
<td>0.91</td>
<td>1.89</td>
</tr>
<tr>
<td>(ii) gravelly soils</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Palatability</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>4. Grazing period</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Cattle</td>
<td>lean period</td>
<td>lean period</td>
</tr>
<tr>
<td>(ii) Sheep</td>
<td>lean period</td>
<td>lean period</td>
</tr>
<tr>
<td>5. Fire tolerance</td>
<td>moderate</td>
<td>moderate</td>
</tr>
</tbody>
</table>
GM-7 : STUDIES ON OPTIMIZATION OF NITROGEN AND HARVEST FREQUENCIES IN PERENNIAL DINANATH AND PENNISETUM TRISPECIFIC HYBRID

(V. Rama Murthy and Vinod Shankar)

The trial was run for the second consecutive year with 4 levels of N; (0, 25, 50 and 75 kg N/ha) and, 3 harvest frequencies; 45, 75 and 120 days for the two grasses viz, Perennial Dinanath (Pennisetum pedicellatum) and Trisankar Pennisetum (Pennisetum trispecific hybrid = P. squamulatum x P. americanum x P. purpureum).

In perennial Dinanath, 3 cuts were taken at 45 days interval, 2 at 75 days and 1 at 120 days, whereas in Trisankar Pennisetum 4 cuts were taken at 45 days interval, 3 at 75 days and 2 at 120 days. Both Green matter (GM) and dry matter (DM) yields were nearly two times of the first years yield. Both N levels and harvest frequencies significantly influenced GM and DM yields in both the grasses (Table 14). Application of 75 kg N and harvest at 75 days resulted in highest DM yield in the perennial Dinanath. Interactions between N levels and harvest intervals were not significant. However, the combination of 75 kg N and harvesting at every 45 days yielded almost equal to that of application of 75 kg N and harvesting at 75 days interval. In Trisankar Pennisetum application of 50 kg N and harvest at 75 days was superior in terms of highest and economic DM yield. Two years Regrowth of Perennial Dinanath and Trisankar Pennisetum

The mean of EI (Efficiency Index) for both grasses was maximum in the 45 days harvest followed by 75 days. The EI showed linear increase with increasing N levels.

Table 14 Green (GM) and Dry (DM) forage yield of perennial Dinanath and Trisankar Pennisetum as influenced by N levels and harvest frequencies.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>N Levels (kg/ha)</th>
<th>Harvest Frequencies (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 25 50 75</td>
<td>45 75 120</td>
</tr>
<tr>
<td>Grasses</td>
<td>Mg ha⁻¹</td>
<td>C.D.5% Mg ha⁻¹</td>
</tr>
<tr>
<td>Perennial Dinanath</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GM</td>
<td>20.4 26.2 28.4 30.9 3.4</td>
<td>25.6 32.3 21.5 4.7</td>
</tr>
<tr>
<td>DM</td>
<td>3.4 4.8 5.2 5.6 0.6</td>
<td>5.0 5.3 4.2 1.1</td>
</tr>
<tr>
<td>Trisankar Pennisetum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GM</td>
<td>37.3 39.4 45.6 43.2 2.9</td>
<td>38.3 46.2 39.7 4.1</td>
</tr>
<tr>
<td>DM</td>
<td>8.8 9.3 10.8 10.2 0.6</td>
<td>9.0 11.2 9.1 1.0</td>
</tr>
</tbody>
</table>
AGROSILVIPASTURE DIVISION

ASP-1: AUTECOLOGY OF FODDER CUM FUEL/SHRUBS

1.3 To select ideal planting stock for plantation of MPTS in red morrum soil

(M.P. Rai)

Observations were recorded for the survival and growth of the MPTS Albizia procera, Hardwickia binata and Ailanthus excelsa planted in the middle of July 1993. After 5 months of their plantation the recorded survival and growth are presented in the table 15.

<table>
<thead>
<tr>
<th>Age of seedlings</th>
<th>Species</th>
<th>Sur %</th>
<th>Ht(cm)</th>
<th>CD (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Albizia procera</td>
<td>3 Months</td>
<td>96</td>
<td>45.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 Months</td>
<td>100</td>
<td>61.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 Months</td>
<td>100</td>
<td>67.2</td>
</tr>
<tr>
<td></td>
<td>Ailanthus excelsa</td>
<td>3 Months</td>
<td>80</td>
<td>39.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 Months</td>
<td>71</td>
<td>35.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 Months</td>
<td>96</td>
<td>30.0</td>
</tr>
<tr>
<td></td>
<td>Hardwickia binata</td>
<td>3 Months</td>
<td>88</td>
<td>38.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 Months</td>
<td>92</td>
<td>38.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 Months</td>
<td>100</td>
<td>51.1</td>
</tr>
</tbody>
</table>

ASP-2: DEVELOPING SILVIPASTORAL SYSTEMS FOR DEGRADED LANDS

2.2 Lopping management studies on selected fodder trees/shrubs in silvipastoral systems

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

During second year of lopping management study, more dry matter yield from suckers were obtained in wide spaced treatments as compared to narrow spaced treatments. The yield levels through lopping and lower branches was obtained in narrow spaced treatments as compared to wide spaced treatments. The yield levels varied from 1.2 - 2.8 t/ha.
Highest pasture yield was recorded in 4 x 5 spacing (2.82 t/ha) as compared to 4 x 4 m spacing (2.34 t/ha). In narrow spaced treatments the yield levels varied from 1.2 - 1.8 t/ha (Fig. 5).

The leaf stem ratio in the sucker and lopped material was found to be in the range of 0.24 - 0.36 and 0.62 - 0.74 respectively (Fig. 6). Within leaf, the pinnae to rachis ratio in suckers and lopped material varied from 2.6 - 2.8.

The average values of CP, NDF, ADF in lopped in sucker material was 12.95%, 40.60%, and 30.03%, in lopped and 11.92%, 39.44%, and 29.91% sucker material respectively.

ASP-3: AGROFORESTRY STUDIES FOR SELECTION OF COMPATABLE TREE SPECIES FOR MAXIMUM PRODUCTION

3.8 Boundary plantation
(M.P. Rai)

Seedlings of Dalbergia sissoo were planted on 17th July, 93 in irrigated farming system and on 25th July 93 in rainfed farming system. Plants were observed for their survival and growth after 150 days of the plantation. The survival of Dalbergia sissoo was same in both the farming condition 93% but, height and collar diameter was more in irrigated system than rainfed system. Detailed observations are presented in Table 16.

<table>
<thead>
<tr>
<th>Farming Systems</th>
<th>Growth period (days)</th>
<th>Survival (%)</th>
<th>Height (cm)</th>
<th>Collar diameter (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated</td>
<td>150</td>
<td>93</td>
<td>92.4</td>
<td>1.12</td>
</tr>
<tr>
<td>Rainfed</td>
<td>150</td>
<td>93</td>
<td>62.3</td>
<td>0.45</td>
</tr>
</tbody>
</table>

ASP-4: DEVELOPMENT OF HORTIPASTORAL SYSTEM FOR WASTELANDS OF BUNDELKHAND REGION

4.1 Growth and productivity of fruit crops in association with grasses and legumes
(S. K. Sharma)

Tree component: Significant decrease in annual increment of plant height and collar diameter was noticed when trees were grown either with grass (Cenchrus ciliaris) or grass plus legume (Styllosanthes hamata) as compared to control, however, no significant change was observed when trees were grown with pure
Fig. 5: Yields from D. cinerea silvipasture

DM yield (t/ha)

Spacing (1=4x4, 2=4x3, 3=4x2, 4=3x2)

- Sucker
- Lopping
- Pasture
- Total

Fig. 6: Leaf stem ratio in D. cinerea
Lopped vs. Sucker Material

Leaf Stem Ratio

Spacing (1=4x4, 2=4x3, 3=4x2, 4=3x2)

- Lopping
- Sucker
legume. No significant change in fruit yield, fuel wood and leaf fodder production of trees at the time of annual pruning was observed when trees were grown with grass plus legume as compared to control. In contrary fuel wood and leaf fodder production reduced significantly when trees were grown with legume. Trees when grown with groes fruit yield and fuel wood production reduced and, leaf fodder production increased significantly (Table 17).

**Pasture Component**

There was no significant effect of trees on pasture production in any combination.

Table 17. Growth and productivity of tree (Zizyphus mauritiana) and pasture (Cenchrus ciliaris and Stylosanthes hamata) components.

<table>
<thead>
<tr>
<th>Treatment Combinations</th>
<th>Control (trees alone)</th>
<th>Trees with C. ciliaris</th>
<th>Trees with S. hamata</th>
<th>Trees with C. ciliaris + S. hamata</th>
<th>CD at 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Tree Component:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Growth:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii. Plant height</td>
<td>155.77</td>
<td>117.02</td>
<td>163.06</td>
<td>137.43</td>
<td>8.23</td>
</tr>
<tr>
<td>(Annual increment, cm)</td>
<td>2.25</td>
<td>2.21</td>
<td>1.96</td>
<td>1.79</td>
<td>0.13</td>
</tr>
<tr>
<td>ii. Productivity:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Fruit yield (t/ha)</td>
<td>0.164</td>
<td>0.125</td>
<td>0.161</td>
<td>0.167</td>
<td>0.023</td>
</tr>
<tr>
<td>(Dry weight, t/ha)</td>
<td>0.106</td>
<td>0.144</td>
<td>0.099</td>
<td>0.107</td>
<td>0.013</td>
</tr>
<tr>
<td>ii. Leaf fodder</td>
<td>0.070</td>
<td>0.082</td>
<td>0.050</td>
<td>0.076</td>
<td>0.007</td>
</tr>
<tr>
<td>(Dry Matter t/ha)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Pasture Component:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry matter production (t/ha)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment Combinations</td>
<td>C. ciliaris</td>
<td>S. hamata</td>
<td>C. ciliaris + S. hamata</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>3.03</td>
<td>4.31</td>
<td>5.17 (3.16 + 2.01)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With trees</td>
<td>4.11</td>
<td>4.02</td>
<td>4.91 (2.87 + 2.94)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD at 5%</td>
<td>0.71</td>
<td>0.53</td>
<td>0.63</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.2 Productivity of kinnow based Sehima dominated hortipastoral system

(S. K. Sharma)

Tree Component: There was no significant effect of Sehima and Sehima plus S. hamata on annual increment of plant height and collar diameter of Kinnow.
Pasture component: Initially there was no significant effect of Kinnow plants on productivity of Sehima dominated pasture with or without S. hamata.

ASP-5: EVALUATION OF NEW GENOTYPES/ IDEOTYPES OF VARIOUS FEED CUM ENERGY PRODUCTION SPECIES

5.1: Genetic improvement of subabul in relation to forage and fuelwood production and quality

(P.S. Pathak)

Performance of promising accession and selections

Fifteen populations planted on highly degraded land in 1989 were felled for growth and above ground phytomass estimation. Out of the 15 populations K-601 gave the peak survival of 75% followed by S-10 with 67.9% and a minimum of 37.1% in SP-1 (Table 18). The survival rates of populations were statistically significant. The collar diameter of populations varied significantly with peak (13.34 cm) in S-10 followed by S-24 (13.06 cm). The poorest collar diameter was μ S-23 (10.08 cm). The dbh also showed significant variations with peak in S-10 (10.06 cm) followed by S-14 (9.94 cm) and the minimum in S-23 (7.66 cm). Bole biomass also varied significantly with peak in S-24 (59.44 kg) followed by S-10 (52.32 kg) and the minimum in S-23 (24.87 kg). Comparing the selections with promising accessions, it was found that K-601, S-10, S-14, S-22 and S-24 gave more than the over all populations mean (41.3 kg). Compared to K-8 (a standard control) the selections S-24, S-10 and S-14 gave an improvement of 48, 31 and 26 percent in the bole biomass. These selections also gave relatively better survival.

Table 18. Evaluation of 15 populations of L. leuconeophila

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Population</th>
<th>Survival (%)</th>
<th>Collar dia (cm)</th>
<th>d.b. h. (cm)</th>
<th>Bole biomass (kg/tree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>K-8</td>
<td>55.9</td>
<td>11.57</td>
<td>9.07</td>
<td>40.00</td>
</tr>
<tr>
<td>2.</td>
<td>K-217</td>
<td>44.7</td>
<td>11.14</td>
<td>8.90</td>
<td>37.67</td>
</tr>
<tr>
<td>3.</td>
<td>K-601</td>
<td>75.0</td>
<td>12.14</td>
<td>9.18</td>
<td>45.03</td>
</tr>
<tr>
<td>5.</td>
<td>K-397</td>
<td>54.1</td>
<td>10.89</td>
<td>8.29</td>
<td>34.39</td>
</tr>
<tr>
<td>6.</td>
<td>K-340</td>
<td>48.8</td>
<td>11.10</td>
<td>8.69</td>
<td>40.50</td>
</tr>
<tr>
<td>7.</td>
<td>K-29</td>
<td>61.9</td>
<td>10.74</td>
<td>8.87</td>
<td>38.51</td>
</tr>
<tr>
<td>8.</td>
<td>IGFRI-23-1</td>
<td>51.8</td>
<td>11.41</td>
<td>9.26</td>
<td>38.13</td>
</tr>
<tr>
<td>9.</td>
<td>SP-1</td>
<td>37.1</td>
<td>10.77</td>
<td>8.53</td>
<td>37.99</td>
</tr>
<tr>
<td>10.</td>
<td>S-10</td>
<td>67.9</td>
<td>13.34</td>
<td>10.06</td>
<td>52.32</td>
</tr>
<tr>
<td>11.</td>
<td>S-14</td>
<td>55.9</td>
<td>11.77</td>
<td>9.94</td>
<td>50.40</td>
</tr>
<tr>
<td>12.</td>
<td>S-15</td>
<td>59.2</td>
<td>10.97</td>
<td>8.97</td>
<td>38.54</td>
</tr>
<tr>
<td>13.</td>
<td>S-22</td>
<td>48.2</td>
<td>11.41</td>
<td>8.88</td>
<td>45.50</td>
</tr>
<tr>
<td>14.</td>
<td>S-23</td>
<td>43.1</td>
<td>10.08</td>
<td>7.66</td>
<td>24.87</td>
</tr>
<tr>
<td>15.</td>
<td>S-24</td>
<td>57.0</td>
<td>13.06</td>
<td>9.53</td>
<td>59.44</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>54.9</td>
<td>11.42</td>
<td>8.98</td>
<td>41.32</td>
</tr>
<tr>
<td>CD at 5%</td>
<td></td>
<td>19.64</td>
<td>1.25</td>
<td>1.06</td>
<td>11.01</td>
</tr>
</tbody>
</table>

*Angular transformation*
ASP-6 : MODELLING FOR GROWTH AND PRODUCTIVITY IN MULTIPURPOSE WOODY PERENNIALS

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

The optimum growth period on the basis of CAI (Current annual increment) and MAI (Mean annual increment) in CD, in Acacia tortilis, Albizia amara, Albizia lebbeck, Dalbergia sissoo and Hardwickia binata would be 11, 8, 9, 7 and 8 years respectively for the site having undulating terrain with red gravelly soil of pH 6.89 - 7.69 with C/N ratio 39.6 - 55.4. Prediction of above ground biomass and under story grass at 10, 12 and 15 years rotation in Acacia tortilis, Albizia amara, Albizia lebbeck, Dalbergia sissoo and Hardwickia binata have been given in table 1. Out of these five species maximum biomass would be in Albizia lebbeck (27-58.8 t/ha) followed by Hardwickia binata, Dalbergia sissoo, Albizia amara and Acacia tortilis respectively but forage production, taking potential crop yield, height and random variation in yield predicts reverse trend with a maximum of 4.92 t/ha/year in association with Acacia tortilis at 10 year rotation and minimum 3.0 t/ha/year with Albizia lebbeck respectively (Table 19).

Through such modelling efforts a research manager/planner can utilize the predicted growth/production performance of tree/grass in a silvipastoral system at a desirable growth stage and may helpful in formulating the developmental programmes for identical situations. The models could be fine tuned by incorporating edaphic and micro meteorological parameters along with tree management practices.

Table 19. Predicted above ground tree biomass/understory grass in different MPTS associated silvipastoral systems

<table>
<thead>
<tr>
<th>Tree species</th>
<th>10 years rotation</th>
<th>12 years rotation</th>
<th>15 years rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Above ground tree biomass (t/ha)</td>
<td>Forage production (t/ha/yr)</td>
<td>Above ground tree biomass (t/ha)</td>
</tr>
<tr>
<td>A. tortilis</td>
<td>3.16</td>
<td>4.92</td>
<td>5.25</td>
</tr>
<tr>
<td>A. amara</td>
<td>4.14</td>
<td>3.36</td>
<td>5.46</td>
</tr>
<tr>
<td>A. lebbeck</td>
<td>27.00</td>
<td>3.01</td>
<td>40.38</td>
</tr>
<tr>
<td>D. sissoo</td>
<td>4.47</td>
<td>3.16</td>
<td>6.24</td>
</tr>
<tr>
<td>H. binata</td>
<td>5.27</td>
<td>3.86</td>
<td>6.71</td>
</tr>
</tbody>
</table>
1.1 Soil test crop response studies under intercropping

(S.B. Tripathi)

Soil P test crop response study under intercropping

Forage yield and P uptake of M.P. Chari + cowpea in kharif and oat + senji in increased significantly with P application, (Table-20). The green and dry fodder and P uptake were maximum at 120 kg P/ha being 37, 31 and 110 percent, respectively in rabi crops. The fodder yield and P uptake of the crops in both the seasons was significantly higher in high P soils than medium and low P soils except green fodder of kharif crops in medium P soils. Mixed crop of M.P. Chari + cowpea recorded 25 and 18 percent higher forage yield and P uptake, respectively than pure M.P. Chari. Similarly, oat + senji had higher fodder yield and P uptake by 13 and 15 percent, respectively than pure oat.

Regression equations of P levels and forage yield of M.P. chari + cowpea were quadratic and based on this, the optimum dose of P was 130, 126 and 117 kg/ha for optimum green fodder of 53.2, 54.2, and 55.8 t/ha, respectively in low (avail. P 5.5-8.2 kg/ha), medium (avail. P 9.2 - 16.0 kg/ha) and high P soils (avail. P 16-25 kg/ha) respectively. The critical limit 1st were of available soil P 21 and 16.5 kg/ha for maximum economic response of M. P. chari + cowpea and oat + senji, respectively.

Table 20 Forage yield, nutrient uptake and soil fertility as influenced by P application.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Forage yield (t/ha)</th>
<th>P uptake (kg/ha-1)</th>
<th>Av. soil P (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Green</td>
<td>Dry</td>
<td>At sowing</td>
</tr>
<tr>
<td>Soil Fertility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>40.45 (39.75)</td>
<td>11.13 (8.91)</td>
<td>11.10 (10.20)</td>
</tr>
<tr>
<td>Medium</td>
<td>44.49 (42.93)</td>
<td>11.95 (9.52)</td>
<td>12.39 (12.18)</td>
</tr>
<tr>
<td>High</td>
<td>46.91 (44.56)</td>
<td>12.52 (9.86)</td>
<td>13.84 (13.80)</td>
</tr>
<tr>
<td>CD 5%</td>
<td>2.85 (0.86)</td>
<td>0.34 (0.31)</td>
<td>1.22 (2.20)</td>
</tr>
<tr>
<td>P levels (kg/ha-1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>36.20 (37.86)</td>
<td>10.01 (8.40)</td>
<td>7.79 (9.47)</td>
</tr>
<tr>
<td>40</td>
<td>43.23 (42.16)</td>
<td>11.68 (9.38)</td>
<td>11.28 (11.75)</td>
</tr>
<tr>
<td>80</td>
<td>46.40 (44.17)</td>
<td>12.63 (9.80)</td>
<td>14.28 (13.07)</td>
</tr>
<tr>
<td>120</td>
<td>49.56 (45.45)</td>
<td>13.15 (10.05)</td>
<td>16.43 (13.95)</td>
</tr>
<tr>
<td>CD 5%</td>
<td>1.09 (0.97)</td>
<td>0.24 (0.20)</td>
<td>1.25 (0.87)</td>
</tr>
<tr>
<td>Crops</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.P. Chari</td>
<td>39.16 (39.39)</td>
<td>10.60 (8.82)</td>
<td>1.43 (11.20)</td>
</tr>
<tr>
<td>M.P. + Cowpea</td>
<td>48.74 (45.43)</td>
<td>13.40 (10.04)</td>
<td>1.34 (12.92)</td>
</tr>
<tr>
<td>CD 5%</td>
<td>1.60 (0.93)</td>
<td>0.23 (0.22)</td>
<td>2.00 (1.08)</td>
</tr>
</tbody>
</table>

Figures in parenthesis indicate for rabi experiment (oat + senji/oat)
Soil Fertility

Low P soils had greater response to added P being 36-67 % during kharif season and 6-29 % during rabi season over their respective controls.

Soil K test crop response study under intercropping

The data (Table-21) indicate that the fodder yield as well as K uptake increased significantly with increasing levels of K upto 90 kg/ha. Intercropping was superior in terms of fodder yield and nutrient uptake to pure crops. The regression equations obtained with K levels and fodder yield of M.P. Chari + cowpea were quadratic in all the three K soils and optimum for dry fodder yield of 154,157 and 159 kg/ha in low (available K 110-138 kg/ha), medium (available K 144-197 kg/ha) and high K soils (available K 250-300 kg/ha), Respectively was found to be 210 and 225 kg/ha for maximum economic response to added K for M.P. Chari + cowpea and oat + senji, respectively.

Table 21 Forage yields, nutrient uptake and soil fertility as Influenced by K· fertilization.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Green (kg/ha)</th>
<th>Dry (kg/ha)</th>
<th>K uptake</th>
<th>Av. soil K (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K levels</td>
<td>At sowing</td>
<td>At harvest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>43.0 (43.48)</td>
<td>13.32 (9.82)</td>
<td>153.24 (99.82)</td>
<td>210 (200) 118 (125)</td>
</tr>
<tr>
<td>Medium</td>
<td>44.9 (45.85)</td>
<td>13.69 (10.17)</td>
<td>169.74 (108.52)</td>
<td>247 (247) 204 (214)</td>
</tr>
<tr>
<td>High</td>
<td>47.99 (45.59)</td>
<td>14.49 (14.44)</td>
<td>181.92 (119.39)</td>
<td>285 (273) 265 (258)</td>
</tr>
<tr>
<td>CD 5%</td>
<td>23.08 (0.49)</td>
<td>0.71 (0.13)</td>
<td>12.00 (8.36)</td>
<td>- - - - - -</td>
</tr>
<tr>
<td>K- levels</td>
<td>(kg/ha)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>41.71 (42.72)</td>
<td>12.99 (9.55)</td>
<td>142.69 (88.94)</td>
<td>194 (195) 184 (188)</td>
</tr>
<tr>
<td>30</td>
<td>45.73 (45.07)</td>
<td>13.78 (10.08)</td>
<td>164.45 (106.97)</td>
<td>233 (225) 192 (194)</td>
</tr>
<tr>
<td>60</td>
<td>49.65 (46.30)</td>
<td>14.32 (10.39)</td>
<td>179.19 (118.48)</td>
<td>271 (261) 201 (206)</td>
</tr>
<tr>
<td>90</td>
<td>47.95 (47.13)</td>
<td>14.51 (10.55)</td>
<td>185.56 (122.59)</td>
<td>292 (280) 206 (209)</td>
</tr>
<tr>
<td>CD 5%</td>
<td>57.50 (0.56)</td>
<td>0.22 (0.15)</td>
<td>14.00 (3.96)</td>
<td>- - - - - -</td>
</tr>
<tr>
<td>Crops</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.P. Chari</td>
<td>44.99 (42.24)</td>
<td>12.86 (9.62)</td>
<td>152.69 (106.66)</td>
<td>246 (238) 193 (195)</td>
</tr>
<tr>
<td>M.P. Chari + cowpea</td>
<td>44.56 (48.37)</td>
<td>14.94 (10.66)</td>
<td>183.28 (111.83)</td>
<td>248 (243) 199 (203)</td>
</tr>
<tr>
<td>CD 5%</td>
<td>0.36 (1.05)</td>
<td>0.22 (0.34)</td>
<td>28.2 (2.69)</td>
<td>- - - - - -</td>
</tr>
</tbody>
</table>

Figures in paranthesis indicate for Rabi experiment (oats + senji/oats)

The response to added K in medium and high K soils ranged from 6-23 and 5-9 percent, respectively for kharif season crops and 8-27 and 3-7 percent, respectively for rabi season crops. The plots under mixed crops had considerably more residual K than plots under pure crops.
1.3 Evapotranspiration studies in forage crops through lysimetry
(Pradeep Behari)

During 171 days of growth period of berseem 659.3 mm cumulative evapotranspiration was recorded which gave mean evapotranspiration of 4.09 mm/day. Cumulative green forage yield of 61.53 t/ha was obtained from lysimeter in five cuttings. On the basis of different cuttings, the mean value of water use efficiency was 15.9 kg/DM/ha mm for lysimeter. Highest green forage yield (17.16 t/ha) was obtained at second cutting. Water use efficiency was also highest in second cutting (28.0 kg/DM/ha mm). Lower green forage and dry matter yield was recorded in third and fourth cuts as crop was damaged due to incidence of root rot disease, however, dry matter yield was highest (13.38 t/ha) in fifth cut.

During kharif 1993, maize + cowpea in paired row spacing was sown in and around lysimeter and during 70 days of crop growth period, the average evapotranspiration for 55 days was 4.1 mm/day which gave 287 mm total evapotranspiration for combined crop growth period. The green forage yield of maize and cowpea was 10.83 and 8.00 t/ha at field and 13.25 and 9.47 t/ha lysimeter, respectively. The water use efficiency of mixed cropping was 16.03 kg/DM/ha mm.

1.4 Effect of leaf manuring on nutrient dynamics and soil productivity
(A.K. Patra and M.R. Pahwa)

The analyses of leaf samples revealed that Sesbania contained highest amount of N (4.72 %), P (0.135%) and K (2.95%). Neem contained 3.37% N, 0.19% P and 1.01% K. Parthenium showed lowest AN content (2.27%), but amount of P and K was almost at par with that of Sesbania. Leucaena contained lowest P (0.12 %) and K (0.69%). The C:N ratio of Parthenium, Sesbania, Leucaena and Neem was 22.25, 10.6, 17.0 and 14.6 respectively. Soluble polyphenol concentration ranged from 0.45% in Sesbania to 1.98% in Leucaena and lignin content varied from 3.7% in Sesbania to 10% in Neem. Both Polyphenol and lignin in Parthenium were lower than rest of the species except Sesbania. The decomposition studies through CO2 evolution technique indicated that the end of 50 days cumulative CO2 evolution was in the order: Neem (250mg), Leucaena (240mg), Parthenium (243 mg), Sesbania (214mg), in 100 g black soil and 237, 250, 262, 221, 182 and 168 mg, respectively in 100 g red soil.

There was a marked increase in bacterial population in Leucaena treated red soil (31.5 X 10^6 cfu/g) on 10th day after incorporation. Population of actinomycetes increased markedly on 15th day as well as again on 30th day. However, addition of leaves + inorganic N showed decrease in Azotobactor population in both the soils.
2.1 Studies on bacterial mediated N2- fixation for increased productivity in forage crops including pasture and tree legumes

(M.R. Pahwa)

2.1.1 Studies on biological nitrogen fixation in mixed legume-grass pasture

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

A pot experiment was initiated using red soil ( sandy loam) to investigate the contribution of legume N to the associated pasture grass under inoculated condition. There were eight treatment combinations consisting of three systems of growing pastures (pure *Cenchrus ciliaris*, pure *Stylosanthes hamata* and mixed pasture of *C. ciliaris + S. hamata*) and three types of inoculation ( uninoculated control, with *Azospirillum lipoferum*-1 in C. ciliaris and inoculation with cowpea *Rhizobium* in S. hamata). Forage yields were recorded in two harvestings taken at 85 and 165 days after sowing. The observations on nodulation and root length were recorded prior to the first cutting. The data indicated that inoculation of S. hamata when both the pasture or with C. ciliaris produced significantly increased nodulation and root length, the maximum being when both the pasture crops were in inoculated and sown as mixed pasture ( S. hamata Ul), 25 nodules/pl, root length - 24.9 cm, S. hamata (l) -53 nodules/pl, root length -26.5 cm/pl). Inoculation of C. ciliaris seed with *lipoferum* and of S. hamata with *Rhizobium* gave 27 and 30.9 % higher dry forage yields over uninoculated control, respectively. Similar trend was observed in crude protein yield. In mixed pasture, when both the crops were inoculated with respective cultures, an improvement in dry biomass (+25.5%) and crude protein yield (+38.8%) in two cuts was obtained over uninoculated mixed pasture crops (Table 22). The effect of N2-fixers was more pronounced during second cut.

Table 22. Dry biomass and crude protein yields (g/plant) as affected by inoculation of pure and mixed pasture crops.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Uninoculation control</th>
<th>Inoculation</th>
<th>D.M. yield</th>
<th>Crude protein yield</th>
<th>D.M. yield</th>
<th>Crude protein yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lst cut</td>
<td>Ind cut</td>
<td>lst cut</td>
<td>Ind cut</td>
<td>lst cut</td>
<td>Ind cut</td>
</tr>
<tr>
<td><em>Cenchrus ciliaris</em></td>
<td>2.00</td>
<td>2.52</td>
<td>0.13</td>
<td>0.16</td>
<td>2.74</td>
<td>3.00</td>
</tr>
<tr>
<td><em>Stylosanthes hamata</em></td>
<td>2.20</td>
<td>2.10</td>
<td>0.42</td>
<td>0.36</td>
<td>3.00</td>
<td>2.63</td>
</tr>
<tr>
<td><em>C. ciliaris + S. hamata</em></td>
<td>4.43</td>
<td>5.48</td>
<td>0.57</td>
<td>0.64</td>
<td>5.53</td>
<td>6.91</td>
</tr>
</tbody>
</table>

*Mean value on inoculation of either crop in mixtures.
2.3 Survey and mapping of soils, grasslands and forage growing areas of Bundelkhand region

(R. K. Tyagi, B.K. Trivedi and A. B. Mazumdar)

During this year, 18 sites in Jalaun, Hamirpur and Banda districts of Bundelkhand region were studied. The observations were recorded on site characteristics, vegetation and forage production. The topography of these sites varied from plane (14) to undulating (3). The grassland of Pachpahara (Hamirpur) were situated on hill and its base. Most of the sites had black soils while some (4) had red soils.

Vegetation:- Reconnaissance survey of the sites revealed that the herbacious vegetation was comprised of perennial and annual grasses, legumes and forbs. At most of the sites, legume component was scarce while at certain sites it was totally absent. Some of the sites were infested with bushes. The prominent species are listed below:

**Perennial grasses:** Bothriochloa pertusa, Dichanthium annulatum, Heteropogon contortus, Iseilema laxum, Sehima nervosum.

**Annual grasses:** Aristida reducta, Brachiaria ramosa, Eragrostiella bifaria, Eragostis pilosa, Setaria glauca, Themada quadrivalvis.

**Legumes:** Alysicarpus monilifer, Indegofera hirsuta, Atylosia scarabaeoides, Stylosanthes hamata.

**Forbs:** Borreria hispida, B. stricta, Evolvulus alsinoides, Ennecostema verticellatum, Justicia simplex, Rungia sp, Suphobia sp.

**Biomass:** The plant biomass at these sites ranged from 88.0 to 49.0 g/m². However, it was more than 400 g/m² at 5 sites, 300-400 g/m² at 4 sites and 200-300 g/m² at 3 sites (Table 23).

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Habitat</th>
<th>No. of sites sampled</th>
<th>Soil type</th>
<th>Grass cover type</th>
<th>Forage Production (Mg/Dm/ha)</th>
<th>Range condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Hilly</td>
<td>1</td>
<td>Red</td>
<td>Sehima-Heteropogon</td>
<td>4.1</td>
<td>Good</td>
</tr>
<tr>
<td>2.</td>
<td>Undulating plains</td>
<td>4</td>
<td>Red to light black</td>
<td>Themeda-Dichanthium</td>
<td>0.8-4.1</td>
<td>Very poor-Fair</td>
</tr>
<tr>
<td>3.</td>
<td>plains with slight/gentle slope</td>
<td>3</td>
<td>Black</td>
<td>Dichanthium-Iseilema</td>
<td>3.7-4.9</td>
<td>Fair-Good</td>
</tr>
<tr>
<td>4.</td>
<td>Flat lands</td>
<td>10</td>
<td>Black</td>
<td>Themeda-Iseilema-Dichanthium</td>
<td>1.9-4.7</td>
<td>Fair-Excellent</td>
</tr>
</tbody>
</table>
Soil fertility status: The soils of grasslands were of varied texture viz. Silty clay, silty clay loam, silty loam, sandy loam, clay, and loam. However, about 50 percent sites had silty clay soils and 25 percent clay soils.

Most of the soils were neutral in reaction (pH 6-8.5). The soil fertility particularly in terms of available N and P was generally low ranging from 125.4 to 247.7 kg/N/ha (except Atarra - 291.6 kg/ha) and 2.8 to 8.96 kg P/ha. However, most of the soils were rich in potassium content. Out of the total 22 sites, 6 were in medium and 12 in high range. The remaining 4 sites were exceptionally high in potassium Konch (594), Collectorpurva (616), Bharva sumerpur (561) and Bamhori/ Bandha mauja (618) kg K/ha.

Plant Nutritional studies

Macro-minerals, except potassium were generally low in the grass samples collected during 1992-93 from different locations of Jhansi, Datia and Gwalior districts.

Grass samples collected from 18 sites in 3 districts of U.P, namely Banda, Hamirpur and Jalaun during 1993-94 were poor in CP content (average 3.7%). Grass samples collected from Pachpahara, Madauha, Khibo, Aatghar, Bamhauri and Dhamna were remarkably low in C.P content. Comparatively low NDF content (below 70%) was found in samples from Collectorpurva A (63.0) Saggar (63.8), Khibo (67.0) and Golra (68.8). Samples collected from Collectorpurva had lowest NDF, ADF and Cellulose content and indicate better digestibility, while samples collected from Pachpahara had relatively poor quality.

SS-3: STUDIES ON FORAGE PRODUCTION UNDER AGROFORESTRY SYSTEMS

3.2 Micrometeorological studies in multicanopy cropping situation

(Pradeep Behari and P.S.Pathak)

Micrometeorological factors in relation to productivity of silvipastoral systems

In 11 years old silvipastoral system two tree species, *Leucaena leucocephala* and *Acacia tortilis* at two spacings were taken along with two established grasses *Cenchrus ciliaris* and *Pennisetum maximum* for system variability and natural climax.
grass *Sehima nervosum* respectively. The observation were recorded three time in a day at fortnightly interval.

**Light Intensity**: The intensity of infiltrated light was maximum during March and September. Under *A. tortilis* the infiltration rate was more than 50% during all the months in both specings except in September (46%). During July, August and March light infiltration was more than 60%.

Under *L. leucocephala* with *C. ciliaris* maximum intensity was obtained in March. Under the trees more than 70% light filtered during August, December and March. Overall more lighted filtered under this tree since they were polarded. Under the same tree with *P. maximum* less than 50% light filtered during February while more than 70% light during July, January and March.

**Temperature**: In case of *A. tortilis* with *Sehima*, the soil temperature remained during July, August, February and March, while in other months, it was more than the open plot. Maximum soil temperature (34.9°C) was observed during July which gradually decreased to minimum (15.6°C) in January. It followed a trend of ambient air temperature.

In case of *L. leucocephala* with *C. ciliaris* and *P. maximum* the soil temperature followed the same trend as in *A. tortilis* with *Sehima*. The ambient air temperature was recorded highest (36.4°C) in March with *P. maximum* while lowest (23.2°C) in January with *C. ciliaris* both under canopy and open plot. Leaf temperatures were maximum in March and minimum in December both for *Cenchrus* and lost *Panicum* at 4 X 4 m spacings. The trend of variation remained same under different tree species and spacings.

**Relative humidity**: The relative humidity (RH) was higher under *A. tortilis* with *Sehima* than open situation. Under *L. leucocephala* with *C. ciliaris* the RH remained lower as compared to *A. tortilis* during all the months. The same tree with *P. maximum* showed mimium RH in March.

**Biomass production**: The peak drymatter production of grasses was minimum with *Sehima* (2.7 t/ha) under *A. tortilis* at 4 X 4 m. spacing while it was maximum (6.2 t/ha) with *P. maximum* in control. *Cenchrus* and *Sehima* were more influenced by tree shade while *Panicum* could produce higher even under shade.
Sehima under *A. tortilis* showed 47 and 54% production of the control plots at 4 X 4 m and 4 X 3 m tree spacings respectively, while under *L. leucocephala, Guinea* showed 72 and 84% yield and *Cenchrus* 68 and 53% yield at 4 X 4 m and 4 X 3 spacing, respectively of the control plots.

**SS-4 : STUDIES ON FORAGE PRODUCTION UNDER PROBLEMATIC SOILS**

4.1 Amelioration and management of salt affected soils

(R.B. Yadava)

**Soil amelioration studies:** Soil samples collected from Deleepnagar (Kanpur) were analysed for electrical conductivity and exchangeable sodium percentage to evaluate the ameliorative effect of grasses (karnal grass, para grass and Setaria) planted with the treatment of control, FYM (5.0 t/ha) and pyrite (1.6 t/ha). After a period of two years of grass growth, Soil pH, EC and ESP decreased in all the treatments (Table 24) However, the reduction in these parameters was more pronounced where pyrite was applied. Among the three grasses, Karnal and Para grass were equally effective while Setaria was the next in ameliorating the sodic soils.

**Plant nutrition:** Except Na, all the nutrients increased with the application of FYM or pyrite over no amendments. Sodium content in the plants decreased with the application of FYM and pyrite.

<table>
<thead>
<tr>
<th>Grasses</th>
<th>Treatments</th>
<th>pH</th>
<th>E.C (dsm⁻¹)</th>
<th>ESP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karnal grass</td>
<td>Control</td>
<td>9.45</td>
<td>0.63</td>
<td>30.8</td>
</tr>
<tr>
<td>FYM @5t/ha</td>
<td>9.30</td>
<td>0.56</td>
<td>28.0</td>
<td></td>
</tr>
<tr>
<td>pyrite @1.6 t/ha</td>
<td>9.15</td>
<td>0.54</td>
<td>24.0</td>
<td></td>
</tr>
<tr>
<td>Para grass</td>
<td>Control</td>
<td>9.45</td>
<td>0.67</td>
<td>30.8</td>
</tr>
<tr>
<td>FYM @5t/ha</td>
<td>9.30</td>
<td>0.56</td>
<td>28.0</td>
<td></td>
</tr>
<tr>
<td>pyrite @1.6 t/ha</td>
<td>9.20</td>
<td>0.52</td>
<td>25.0</td>
<td></td>
</tr>
<tr>
<td>Setaria</td>
<td>Control</td>
<td>9.50</td>
<td>0.65</td>
<td>32.0</td>
</tr>
<tr>
<td>FYM @5t/ha</td>
<td>9.40</td>
<td>0.58</td>
<td>29.6</td>
<td></td>
</tr>
<tr>
<td>Pyrite @1.6 t/ha</td>
<td>9.30</td>
<td>0.55</td>
<td>28.2</td>
<td></td>
</tr>
</tbody>
</table>
4.2 Amelioration And Management Of Acid Soils For Forage Production

(S.B. Tripathi and R.B. Yadava)

Forage yield and nutrients uptake

The forage yield of grasses, range legumes and grass-range legume mixtures increased by 41, 67 and 41 percent, respectively in strongly acid soil and by 39, 48 and 37 percent, respectively in slightly acid soil due to lime application (aggregate of 10 cuts). Guinea, stylo and its mixture responded more to liming as compared to setaria, siratro and other grass legume mixtures. However, setaria, siratro and siratro mixture gave higher biomass yields both under limed and unlimed conditions. Amongst grasses, range legumes and their mixtures, the mixed stand of setaria + siratro produced highest yields in both the soils. The productivity of slightly soil was more than the strongly acid soil. On an average, the productivity of strongly and slightly acid soils was 47 and 54% in unlimed condition and 68 and 76% in limed condition, respectively of the normal soils. The nutrients uptake (N, P, K, and Ca) by the crop plants followed the similar trend as that of forage yields.

Soil fertility: The results on soil fertility after a period of three years indicate that soil pH of unlimed soils decreased by 0.1 to 0.2 units whereas it increased by 0.6 to 0.9 unit under limed soils over the initial pH values. The available nutrients status (N, P, K and Ca) were reduced in unlimed and limed soils except Ca in limed soil, where it was improved over its initial content.
DIVISION OF PLANT ANIMAL RELATIONSHIP

Par -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

(Bandla Srinivas and N. C. Verma)

Animals were fed on mixed dry grass *ad lib* and about 7.5/11.5 kg berseem (*Trifolium alexandrium*) to meet maintenance requirement. Animals of treatment one (T1) were provided concentrate mixture to meet production requirement and served as Control. In T2 and T3 concentrate requirement was reduced by 25 and 50 percent, respectively and provided a substitution of urea- molasses mineral - block (UMMB) lick.

After 75 days of interval, a digestibility trial was conducted for 7 days. Blood samples were collected before and after the digestibility trial. UMMB lick intake in T2 and T3 was 205 and 155 g/d, respectively. Total dry matter intake in T1, T2, and T3 was 2.29, 2.04 and 2.10 kg/100 kg body weight, respectively. Fat corrected milk yield was 5.76, 5.61 and 4.61 kg/d, in T1, T2 and T3, respectively. There was no significant difference in NPN content of milk as well as dry matter or organic matter digestibility coefficient whereas CP digestibility coefficient in T1, T2 and T3 was 61.31, 62.10 and 53.73 %, respectively and varied significantly (P<0.01). Ammonia content in the blood was within normal physiological level (less than 2%) in all treatments. DCP content of ration was 6.88 in T1, 7.37 in T2 and 5.65 % in T3. DCP intake in T1 and T2 was sufficient to meet maintenance and production requirements but in T3, it was 29% less. UMMB lick supplementation could able to supply only 21 per cent less of reduced concentrate requirement in this treatment. Thus, UMMB lick supplementation can reduce concentrate requirement in low yielding cattle by 25 % without effecting milk yield and fat yield.

PAR - 2 : EVALUATION OF FORAGE QUALITY AND FODDER PRODUCTION SYSTEMS FOR LIVESTOCK PRODUCTION

2.1.2 Effect of feeding different levels of RDN and UDN on growth rate of growing alves

(V.C. Pachauri and A.B. Mojumdar)

All the animals were fed on sorghum silage *ad lib* as basal roughage and concentrate mixture consisting of unprotected groundnut cake (Group I) or 1% formaldehyde treated groundnut cake 60% (Group II) or 40% (Group III). There was
no significant change in DM, OM, CP or EE digestibility. But significant improvement among three groups were observed for of 39.24, 49.06, 52.64, NFE ; 61.48, 61.68, 61.94, NDF; 47.43, 47.10, 56.08, ADF; 32.72, 36.29, 49.46; and GE64.94, 63.92, 68.50; in group - I, II, and III, respectively and it can be attributed to improved supply of UDN in experimental groups. Dry matter intake in group I, II and III was 2.29, 2.60 and 2.55 kg/100 kg body weight. DCP (g/d) and TDN (kg/d) intake in corresponding groups were 272, 393, 352 and 2.07, 2.41, 2.32, respectively. Serum urea was significantly lower in group II (19.76) compared to group I (25.91) which indicates better utilization of protein in group II. Growth rate (g/day) was also higher in group II (496) than group I (460) and III (460). Thus, 60% crude protein protection of groundnut cake in concentrate mixture was advantageous.

2.1.3 Effect of feeding proteins of different degradability on milk production and efficiency of nutrient utilization in buffaloes (R.S. Upadhyay, V.S. Upadhyay and A.B. Mojumdar)

1. All the six buffaloes were allowed to graze about 8 hrs./day in a Sehima Heteropogon dominant grassland. Concentrate mixtures vary in different protein sources such as cotton- seed cake (CSC; Group I) groundnut cake (GNC; Group II) and linseed cake (LSC; Group III) was offered to each group alternatively for a period of 20 days under 3X3 switch over design. The feeding of CSC had positive impact on concentration of serum protein, albumin and globulins while GNC and LSC had negative impact. The changes in serum urea level in Group I was negative in buffaloes passing first (FTL) and third trimester (TTL) of lactation. Serum urea concentration in Group II showed marginal positive change in FTL while slight negative change in TTL buffaloes. There was a positive change in serum urea concentration in Group III on both FTL and TTL buffaloes. Serum glucose concentration in buffaloes appears to be associated with stage of lactation rather protein source as the FTL had 6 to 9 units higher glucose concentration than buffaloes in TTL.

Milk yield (7% FCM, kg/d) of FTL and TTL buffaloes were in three groups I, II and III 6.46 and 5.61; 6.98 and 5.60; 7.24 and 5.62, respectively. The decline in milk yield (change from initial milk yield) was i.e. 29.86 and 33.05 % higher Group I in FTL and TTL respectively Group II trend with respect milk yield such as positive change (8.05) in FTL but negative (0.118) change TTL in buffaloes. The percent change in milk yield of Group III was positive in FTL (3.72) and TTL (0.18) buffaloes.

2. The basal ration for all the buffaloes consisted of 30 kg unchaffed green berseem fodder + sorghum silage ad lib and concentrate mixture to meet requirements. The concentrate mixtures given to three groups of buffaloes were similar as reported in experiment 1. During 90 days lactation study, the
data on intake and digestibility of dry matter have been presented in table 28.

Table 28. Intake and digestibility of dry matter in lactating murrah buffaloes.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Intake kg/100kg b.w.</th>
<th>Dry matter digestibility coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSC (G pi)</td>
<td>2.6 ± 0.10</td>
<td>129.5 ± 3.93</td>
</tr>
<tr>
<td>GNC (G p ii)</td>
<td>3.0 ± 0.09</td>
<td>146.55 ± 3.53</td>
</tr>
<tr>
<td>LSC (G p iii)</td>
<td>2.8 ± 0.20</td>
<td>136.37 ± 8.19</td>
</tr>
</tbody>
</table>

The changes in serum concentrations of protein albumin and globulin were positive and higher in CSC group as compared to those in GNC and LSC groups. The feeding of GNC also resulted in positive change in serum level of protein, albumin and globulins but negative change in serum urea level. However, the feeding of LSC was associated with negative change in serum protein, albumin and globulins. The positive change in the concentration of serum protein of buffaloes given CSC may be indicative of quantitatively higher protein absorption from the small intestine.

The persistence in the lactation was better on GNC group followed by LSC and CSC groups. The yield of 7% FCM (kg/d) in three groups were 6.65, 7.72 and 7.01, respectively. The live weight gains in CSC, GNC and LSC groups were 261, 59 and 72 g/d, respectively.

3.3 Evaluation of silvipasture system for livestock production under mixed species grazing

(V.S. Upadhyay and P.S. Pathak)

Studies were continued for fifth year with cattle, sheep and goats to study the performance of livestock in terms of biological and economic efficiency on silvipasture system.

Performance of first calvers: Three animals calved previously were continued in milk during the year. The total milk produced and concentrate consumed were 5209 and 3998 kg, respectively. The full lactation milk yield for three cows were 1906, 1994 and 1938 kg, respectively.
Performance of breedable sheep: There was no lambing during this year. The probable reasons may be that few sheep were too old and remaining were too young.

Performance of breedable goat: Twelve breedable Barbari goats were distributed into two equal groups and maintained on silvipasture grazing without concentrate supplement (Group I) and with concentrate supplement @ 250 g/h/d. All the goats from each group gave birth to 18 kids. Out of which 11 were males and seven females. The number of kids born from Group II were 7 and 11 respectively. The average birth weight of the kids was 0.98 ± 0.4kg. The birth weight of the kids born in season I (January to June) and season II (July to December) were 1.00 and 0.97 kg, respectively. Besides experimental goats, one goat under replacement stock also gave birth to two kids. However, out of total 20 kids born, seven died and this mortality rate in kids was 35 per cent.

3.3 Nutritional evaluation of barley fodder grown under artificial conditions

(A.K. Misra and S.B. Maity)

Four adult crossbred bullocks were fed ad lib on barley fodder grown under artificial conditions (BFGA) during summer. CP, EE, CF, NFE, total carbohydrates (TCHO) and ash in BFGA were 14.43, 3.23, 17.11, 61.11, 78.22 and 4.12, percent respectively on OM basis respectively.

The voluntary intake fresh BFGA by adult bullocks weighing 352 kg was 44.47kg/d, 6.18 kg/d on dry matterbasis. The mean digestibility coefficients of DM, OM, CP, EE, CF, NFE and TCHO were 67.94, 72.21, 69.40, 66.95, 62.13, 75.89 and 72.93, respectively. The fodder contained 9.91% DCP and 72.40% TDN with nutritive ratio of 6.30 . The mean daily intakes of CP, DCP and TDN were higher than the maintenance requirement of adult bullocks. The overall results indicated that nutritive quality of fodder produced on Fometa machine could provide little above the maintenance requirements of bullocks.

3.5 Investigations on antiquity constituents of shrubs and trees

(B.K. Bhadoria)

The leaves of Albizia amara, were investigated for antiquity factors .Total polyphenols and condensed tannin were 18.1 and 6.9 percent, respectively. The
biological activity of protein precipitating tannins (4.6 A^{510/9}) and protein precipitating capacity (2.2%) were maximum during July.

The powdered leaves of *Albizia amara* contained saponins. The saponin on acid hydrolysis yielded a triterpenic acid indenified as chinocystic acid, glucose and galactose. The petroleum ether, benzene and ethylacetate soluble fraction on the column chromatographic analysis separately yielded an aliphatic hydrocarbon, β-sitosterol and flavonoid.
DIVISION OF SEED TECHNOLOGY

SPR-1: STUDIES ON CROP GEOMETRY, FERTILIZER USE AND MOISTURE STRESS IN RELATION TO SEED PRODUCTION IN FORAGE CROPS

1.1 Fertilizer use, planting geometry, dates of sowing, seed rates and cutting management studies in cowpea and lucerne for seed production

(P.S. Tomer and S. N. Singh)

1.1.1 Seed production efficiency of promising varieties of cowpea in relation to date of sowing

Cowpea sown on 10th July produced significantly higher seed yield (930 kg/ha) than that of 30th July (885 kg/ha) and the lowest yield was obtained with 19th August sown cowpea (360 kg/ha). Further, NP-3 (925 kg/ha) and IGFRI-450 (905 kg/ha) excelled IFC-9304 (470 kg/ha) and IFC-901 (595 kg/ha) in seed yield.

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

Seed as well as forage yield of lucerne remained unaffected due to different seed rates (3, 6, 9, and 12 kg/ha). However, seed yield was remarkably increased (77 kg) with uncut 23 kg with three cut and forage yield decreased with lesser number of cutting. In terms of gross income, practice of taking more number of cuttings proved superior (Rs. 6227.16/ha on three cuts) over uncut (Rs. 2710.84/ha).

1.2 Agronomical investigation in pasture legume seed production

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

Effect of cutting management and KNO3 foliar feeding on seed production of *Stylosanthes hamata* grown with and without irrigation

Uncut crop yield higher seed (336.72 kg/ha) compared to seed yield crop at two month after sowing one cut (317.20 kg/ha). The crop received imigation after one month of cutting recorded significantly higher seed yield (339.34 kg/ha) than unirrigated crop (314.40 kg/ha). Foliar spray of KNO3 twice up to 6 kg/ha linearly increased the seed yield up to 372.5 kg/ha, compared to seed yield with control treatment, 271.0 kg/ha.
1.4 Agronomic Investigations for increasing seed yield in grasses

(G.K. Dwivedi)

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

Increasing doses of nitrogen in Setaria Sphacelata upto 60 kg/ha gradually increased the seed yield of grass to 107.78 kg/ha. Among legumes, the association of Sesbania sesban produced the highest seed yield (84.05 kg/ha). These seed yields were equivalent to 40 kg fertilizer N/ha (81.9 kg/ha) and proved better than the application of 20 kgN/ha (67.63 kg/ha), sole grass produced minimum seed yield (48.01 kg/ha). Besides, enhancing seed yield of grass and effecting economy in fertilizer N, the pasture legumes gave forage yield of Clitoria ternatea (12.6 t/ha), Sesbania Sesban (8.52 t/ha), Desmanthus virgatus (4.05 t/ha), Desmodium virgatus (1.78 t/ha) and Stylosanthes scabra (1.38 t/ha).

SPR -2 : SEED BORNE DISEASES AND THEIR CONTROL IN FORAGE CROPS

(S.N. Singh)

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

A field trial was conducted to study the efficacy of seed treatment with fungicides and foliar spray (Thiram, Plantvax and Bavistin @ 0.15 and 0.3%) against seedling and foliar diseases of lucerne cv. IGFRI-244. Among all combinations, Bavistin alone (0.3%) was the most effective in controlling the seed-rot and seedling mortality (0.33-3.3%) with significantly higher plant stand over untreated control (28.3% mortality) followed by Bavistin + plantvax (1:1 combination). The leaf blotch infection caused by Alternaria and Curvularia spp. in untreated plots ranged from 0.3 -24.8% leading to severe defoliation. The prevalence of alfalfa mosaic virus (AMV) was up to 12% with smaller and chlorotic leaves. The average progressive increase in the intensity of the rust disease as measured by the score per plant was 0.3 - 0.63 while in control plots an average of 28% of tillers showed rust infection. Lucerne seeds from fungicidal sprayed plots had meagre seed- borne pathogens with less Fusarium seed decay (5-10 colonies/100 seeds) than those from unsprayed plant (50-140 colonies /100 seeds). The spray of fungicides (Bavistin and Plantvax)
significantly reduced the seed-borne Fusaria in both seed coat and embryo tissues which significantly correlated with higher germination (95-97%) in sprayed plants than those from unsprayed plants (62%) on in vitro tests.

2.2. Seed-borne fungi affecting seed of rice bean

In all the eight samples, Fusaria were associated in large number (2.3-32.3%). Out of 15 isolates, 5 (Macrophomina phaseolina, Fusarium moniliforme, F. semitectum, Curvularia lunata and Alternaria spp.) were most virulent causing and post emergence seeding mortality to the extent of 11.5 - 32.3 per cent.

3.1 Studies on insect pests and pathogens in seed storage

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

Among the storage containers, ploythene bags and plastic Jars were found best for storing the seeds with and without seed treatment for 14 months with a germinability varying from 75 to 97 percent. The treatment of seed with fungicides viz. Bavistin alone or Bavistin + Malthion @ 0.1% (1:1) was best in maintaining the viability of seed upto certification limits (more than 80% germination). It had advantage of less seed invasion by storage fungi and seed damage by Callosobruchus in Dolichos and Trogodeirma in maize over untreated check during long storage period. A positive correlation was obtained between total mycoflora (Aspergillus spp.) and germination with the increase in storage period.

2.3. Effect of botanicals on insect-pest pathogens and germinability in Dolichos and maize seeds

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

Dolichos and maize seeds were stored in polythene bags (700 gauge) after treating with the extract of botanicals @ 0.5 ml/kg seed in order to assess their efficacy against the infestation of insects and storage fungi under ambient condition.

Moisture content and germination: There was no significant variation in moisture content with respect to different doses of botanicals viz. Croton tiglium, Acorus calamus, Azaderacta indica and Vitex negundo and storage period. There was, however, gradual increase in the moisture content of untreated seeds with a significant reduction in the germination (52-64%) as compared to treated seeds (94-96%) after 20 months of storage in both the seeds.
**Bioefficacy**: All the botanicals at lower doses reduced the bruchid and *Trogoderma* infestation significantly up to 20 months of storage as compared to untreated control (33-44.5 per cent). Among all seed protectants, Croton and Acorus proved excellent for the control of bruchids with very less invasion of *Aspergillus* species in both kinds of seeds up to 20 months of storage confirming the previous years results. On the contrary, in the untreated seeds the bruchids and Trogoderma infestation was noticed after 3 months of storage. A drastic deterioration occurred due to fungal population causing reduced germinability and vigour after 12 months of storage.

The incidence of fungi viz. *Aspergillus flavus*, *A. ruber*, *A. glaucus* and *Rhizopus* spp. was very low in treated seeds as compared to untreated seeds. An increase in moisture content due to prevalence of bruchids is responsible for increased population of these storage fungi. Thus the increase in storage fungi was correlated with the insect infestation.
DIVISION OF PLANT PROTECTION

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

1.1 Disease for forages and their management

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

1. Screening for resistance

**Cowpea** : Varieties IFC-9304, UPC-93-1, 93-2, 93-3, UPC-5286 were resistant to root rot (*Rhizoctonia bataticola*), UPC-93-1 was also resistant to mosaic virus.

**Sorghum** : Among elite selections (15), IS-14532, 22386, 22032, 651, 2192, 2472, 20013, 2179 and among hybrids Hyb. 14109 (ICSA 88009 x E 36-1), Hyb. 14133 (ICSA 89 x NJ 2122), Hyb. 14136 (ICSA 93 x NJ 2122) were moderately resistant to Anthracnose (*Colletotrichum graminicola*), sooty stripe (*Ramulispora sorghi*) and zonate leaf spot (*Gloeocercospore sorghi*).

**Bajra** : Varieties TNSC-4, IP-3613, APFB-5, UUJ-2, MP-260, MP-261, PCB-150, CO-8, RFB-3 and UUJ 4-M showed resistant reactions to downy mildew (*Sclerospora graminicola*) and rust (*Puccinia penniseti*).

**Maize** : Lines APFM-12, FML-15, GBM 84-1 and 84-3 were resistant to downy mildew (*Peronosclerospora sorghi*) and leaf blight (*Helminthosporium maydis*).

**Lucerne** : Varieties LLC-3, RLS-88, Anand -6 were highly resistant to downy mildew (*Peronospora trifolii*), rust (*Uromyces striatus*) and leaf spots (*Pseudopoziza medicagin*).

**Berseem** : Out of the 22 varieties JB 92-1, JHB-146, JHB 93-1, BL-116 and BL-112 were moderately resistant to root/ stem rot (*Rhizoctonia solani, Fusarium Semitactum* and *Sclerotinia trifoliorum*) under field and net house conditions.

**Shaftal** : Out of 8 varieties, SH 69 and SH 77 were resistant to root rot (*Rhizoctonia solani*) and rust (*Uromyces sp.*)

**Oat** : Out of 300 germplasm 29 varieties screened, varieties JHO-851, JHO-996, JHO-994, JHO-995, DFC-57, OL-611, UPO-212, UPO-242 JHO-891, 892, 893 and OL-529 showed resistant reactons to leaf blight /blotch (*Helminthosporium avenae*)
2. Assessment of losses

The losses in green forage yield in lucerne due to downy mildew (*Peronospora Trifolii*) and leaf spots were maximum in third cut (17.9%) followed by fourth and second cut. Cumulative losses in four cuttings at 30 days interval were 13.5%.

3. Laboratory studies

**Effect of temperature and light on growth and sclerotia formation of Sclerotinia S. trifoliorum** the causal organism of stem rot of berseem was isolated on PDA. The best growth and sclerotia formation was achieved at 10°C with 12 hrs light.

**Ecological And Control Studies Of S. Trifoliorum**: Isolation of the pathogen from 0-10 cm soil layer revealed that the fungal propagules were confined to 0-5 cm. soil layer, maximum propagules were surviving at a depth of 2 cm. Soil drenching with Bavistin 0.2% solution at 5 cm depth killed the pathogens.

**Effect of neem components on the growth and multiplication of : Rhizotonia, Sclerotinia and Fusarium**: Various components viz. Neem leaves, Kernel, Oil and Cake were evaluated in vitro for their effect on growth and multiplication of the soil fungi *Rhizoctonia, Sclerotinia* and *Fusarium*. All the component inhibited the growth and multiplication, however, maximum inhibition (76%) was caused by neem cake followed by neem oil (52%).

**Effect of VAM weedicides on the growth and multiplication of Sclerotinia trifoliorum**: Atrazine, Glyopholate, Basafin and Triflurolin were tested at 100, 500, 1000, and 2000 ppm concentrations. All the weedicides were growth promoting at lower concentration (100 ppm), and fungicidal at higher concentrations (500 ppm and above).

**Effect of VAM (Glomus fasciculatum) on the incidences of Rhizoctonia, bataticola and Sclerotium rolfsi on cowpea**: Seed treatment with VAM had less disease incidence (28%) in comparison to control (72%) when sown in pots filled with sick soil. Besides reduction in the disease incidence there was significant increase in yield attributes.

1.2 Insect associated with grassland and their management

(N.K. Shah)

Bio-efficacy of two commercial formulations of Azadirachtin viz. Azabin and Actin-50 at 0.1% and 0.025% concentration respectively, neem seed kernel extract (NSKE) and neem leaf extract (NLE) at 2 and 20% respectively and malathion at 0.075% concentration as a check for the management of grasshopper complex on *Cenchrus setegerus* were evaluated. Minimum leaf damage and highest green
forage yield was in plots treated with malathion (0.075%) followed by Azabin (0.1%), NSKE (2%), NLE (20%) and Actin-50 (0.025%). Malathion, Azabin, Actin-50 NSKE and NLE treated plots showed an increase of 4.7, 4.0, 1.7, 3.7 and 1.3 t/ha of green forage yield over untreated plots.

1.3 Insects associated with leguminous forages and their management (K.C.Pandey and S.A. Faruqui)

1. Evaluation of germplasm material for insect-pest resistance/tolerance


Lucerne: Based on field reaction to alfalfa weevil and aphids following lines have been identified as least susceptible, IL-4124, 4125, 4138, 4142, 4150, 4176, 4184, 4187, 4188, 4192, 4194, 4200, 4201, 4202, 4203, 4205, 4208, 4218, 4219, and Anand-2.

2. Evaluation of neem products for their insecticidal action in cowpea and lucerne

Cowpea: Three neem based preparation viz. Neem Seed Karnal Extract (NSKE) at 2% and 3% , Deoiled Neem Seed Kernal Extract (DONKE) at 2% and 3% , Achook at 0.33% and 0.50% were tested alongwith recommended insecticide endosulfan (0.075%) with untreated control applied at 15, 30 and 45 days old crops. All the treatments gave superior control of defoliators and leaf hoppers over untreated control based on per cent damage in leaves. Among various neem products Achook at 5% had least damage (6.63%) upto 45 days of plant growth but none of the neem preparation controlled defoliators after 45 days over endosulfan. Green fodder yield was highest in Achook @ 5% (32.8 t/ha) followed by endosulfan @ 0.075 % (32.63 t/ha). The net gain in these treatments was 20.1 % over untreated.
Lucerne: Three neem based preparations viz. neem seed kernel extract (NSKE) and Deoiled neem seed kernel extract (DONKE) at 2% and 35%, Achook at 0.33% and 0.50% were evaluated alongwith recommended insecticide, endosulfan 0.75% and untreated control. These chemicals were applied 15 days after 1st cut and 5 days after 2nd cut. The lucerne weevil population was least in endosulfan treated plots. Mean population was 7.56 /ft² as compared to 18.65 /ft² in untreated control. The performance of different neem products was as follows; DONKE (3%), NSKE(3%), NSKE(2%), DONKE (2%), Achook (1.5 ml %), Achook (.33%). Aphid population appeared after 2nd cut only and ranged from 1.23/10 leaves in untreated control to 10.47 to leaves in endosulfan treatment. Mean jessid population control was superior in all treatments in comparison to untreated. Least population was recorded in endosulfan treatment (2.38/sweep) which was at par with Achook (0.5% and NSKE (3%). Total green fodder yield (t/ha) of three cuts was highest in endosulfan (18.30) as compared to control (14.69).

Laboratory experiment

Aqueous extracts of Neem seed kernel and Deoiled neem seed kernel were tested at 2, 3, 4 and 5% concentration on cowpea semilooper (Plusia nigrisigna) and lucerne weevil (Hypera postie). Higher concentration of 4 and 5% gave 90% mortality of semilooper and 75% mortality of lucerne weevil. Effect of 2% and 3% NSKE and DONKE delayed the maturation period of larvae to 5.95 days. Lucerne weevil larvae growth was also delayed by 4.5 days.

1.4 Insects associated with non leguminous forages and their management

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

Pest-parasites-predators association in cropping system

The major insect pest species infesting sorghum and maize crops were shoot-fly Atherigona soccata, aphid Rhopalosiphum Maidis, Stem borer, Chilo Zonellus, sorghum earhead midge, Contarinia sorghicola and earhead caterpillar, Eublemma sp. Parasiotoldes recorded on shootfly were Trichogramma sp., Betheplectes sp. and Tetrastichus sp. Apanteles flavipens, Trichogramma sp. Bracon sp. and Telenomus sp. were recorded on Chilo zonellus. Coccinellids and syrphid fly were observed as predators of aphids in these crops. Apanteles sp. and Eupelmus popa
were recorded on sorghum midge. Apanteles sp. and *Eupelmus popoa* were recorded predating on soft bodied insects. *Apanteles* sps. and *Trichogramma* sps. were recorded on grasshopper *Chrogonus*

**Germlasm screening**

Maize germplasm screened for resistance to insect pest showed that lines J-1006, FML-15, FML-13, W-1 and AT were resistant (less than 5% infestation) to shootfly. The damage by stem borer was not significant.

Fifty three new accessions of sorghum screened for their reaction to insect pests showed that IS-3289, HyP14102, 14133, 14136, IS-1133, 3274 had the minimum damage (less than 5% by shootfly).

Fourteen multicut and single cut sorghum genotypes screened for shootfly resistance showed IS 2189, 20013, 20751, 22386, 2472, were least effected IS92109, 92132, 92125, 92128, 2317, 2318, 2320, 2323, 2327 and 2329 had less than 5% shootfly attack as indicated in the germplasm screening.

Seventy three *Cenchrus Ciliaris* lines screened showed IGFRI-638, 3059, 4101, 630 and 8-2-3 had minimum leaf damage score (scale 0-5). In another trial of eight promising selections of *C. ciliaris*, the material showed least damage by insect pest (rated at 1 in 0-5 scale) were IGFRI-675, 8-4-10, 310-8 and 3133.

**Evaluation of neem products for control of sorghum foliage pests**

Best control of shootfly was obtained (3.53%DH) in the treated seed with carbofuran (1%w/w) and one spray of Azabin (0.1% at 20 days). However, highest green fodder was obtained (28.38 t/ha) in Seed treatment + Neem Kernal Water Extract (NKWE) with 5.97% DH as against, 26.16 t/ha in ST + Azabin. The results obtained are given in table 29.

**Table 29** Evaluation of neem products for control of sorghum shootfly.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Shootfly caused DH% (Mean)</th>
<th>Green fodder yield t/ha (Mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1  Carbofuran (ST 1% w/w)</td>
<td>5.97</td>
<td>23.96</td>
</tr>
<tr>
<td>T2  NKWE (3%, 2 sprays 10, 20 days)</td>
<td>8.73</td>
<td>23.58</td>
</tr>
<tr>
<td>T3  Actin (.025% 2 sprays 10, 20 days)</td>
<td>4.90</td>
<td>24.83</td>
</tr>
<tr>
<td>T4  T1 + NKWE (3% 1 spray, 20 days)</td>
<td>5.97</td>
<td>28.38</td>
</tr>
<tr>
<td>T5  T1 + Actin (.025% 1 sprays , 20 days)</td>
<td>5.13</td>
<td>26.75</td>
</tr>
<tr>
<td>T6  Azabin (.1% 2 sprays 10, 20 days)</td>
<td>13.47</td>
<td>24.42</td>
</tr>
<tr>
<td>T7  T1 + Azabin (.1% 1 spray 20 days)</td>
<td>3.53</td>
<td>26.16</td>
</tr>
<tr>
<td>T8  Control</td>
<td>17.93</td>
<td>21.66</td>
</tr>
</tbody>
</table>
1.6 Vesicular- arbuscular mycorrhizal (VAM) fungi and nematode activities in forage production

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

Response of MPTS to VAM inoculation

Four tree species were evaluated for their response to VAM inoculation of which Hardwickia Binata failed to germinate. Inoculation with required inoculum level of Glomus fasciculatum was done at the time of sowing and after germination one seedling in each polythene bag filled with sterilised soil was allowed to grow. An uninoculated control was maintained for each species. Plant growth characters and mycorrhizal counts were measured after 90 days (Table 30) A. lebbek exhibited better symbiosis with G. fasciculatum as shown by conspicuous increase in plant growth parameter as well as percent root colonisation and spore counts as compared to other.

Integrated management of root-knot nematode on cowpea

In microplot experiment efficacy of VAM (G. fasciculatum) and Achook (neem product) alone and in combinations were evaluated in managing the root-knot nematode (M. incognita) on cowpea. It was observed that G. fasciculatum along with Achook seed treatment @ 0.5 % w/w increased the green fodder yield by 31.49 % over the control followed by G. fasciculatum plus Achook as soil application (14.79% increase) . Similarly , nematode population as well as root-knot index was also low under these treatments . G. fasciculatum being a biological control agent and Achooka plant product with no hazardous effect can safely be used in an integrated management of nematodes in forages.

Laboratory studies

Four commercial neem products with different concentrations were evaluated for their bio-toxicity to root-knot nematode in vitro conditions at 0.05% concentration. There was very little larval mortality upto 12 hrs. of exposure in all the test products. however after 71 hrs 34 and 31 % mortality was recorded in case of Actin and Achook respectively. Same chemicals at 0.2% concentration induced 100% mortality at 72 hrs. Being plant product, they exhibited slow killing action as compared to the quick action of the nematicides. Similarly, inhibition in larval hatching of M. incognita after 72 hrs in different concentrations, ranged between 7-92%. Achook and Actin were
found to be most effective as they resulted into 92 and 88.5% inhibition respectively in 0.2% concentration.

Table 30 Effect of VAM inoculation on MPTS seedling growth.

<table>
<thead>
<tr>
<th>Tree species</th>
<th>Plant Groth Characters</th>
<th>Mycorrizal infection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% increase over control</td>
<td>% root colonization</td>
</tr>
<tr>
<td></td>
<td>root length</td>
<td>fresh root weight</td>
</tr>
<tr>
<td>Acacia tortilis</td>
<td>7.84</td>
<td>6.66</td>
</tr>
<tr>
<td>Albizia lebbek</td>
<td>18.05</td>
<td>3.97</td>
</tr>
<tr>
<td>A. amara</td>
<td>4.11</td>
<td>2.73</td>
</tr>
</tbody>
</table>

1.7 Nematodes associated with range legumes, range grasses, fodder trees and shrubs and their management

(M.I. Azmi)

Preliminary survey revealed that are nematodes much abundant in surveyed area (C.R. Farm of this Institute). These nematodes are mainly associated with plant-parasitic nematodes like, root-knot, root-lesion and stunt nematodes in range forages.

Effect of burning on nematode population

Annual burning in summers decreased nematode population by 65% in unfertilized and 50% in fertilized field. Whereas 80% reduced in unfertilized field and 70% in fertilized field during winter burning. In biennial burning, nematode population decreased 55% in unfertilized and 45% in fertilized fields due to summer burning, and 76% decreased in unfertilized field and 70% in fertilized fields during winter burning. Trinennial summer burning reduced 70% nematode populations in unfertilized and 61% in fertilized fields. There was 90% and 81% reduction in nematode populations observed in unfertilized and fertilized fields due to winter burning respectively (Table 31).

Nematode management in tree seedling with Azabin

Effect of Azabin was evaluated for the management of plant-parasitic nematodes of the seedlings of *Acacia nilotica*, *Albizia lebeck* and *Leucaena leucocephala*. Two treatments viz. soil application @ 0.06 ml per soil per water and seed soaking for 24 hrs. @ 10 ml per L water were given. For the comparison Furadan 3g, Soil application @ 0.03g per, Soil and Seed soaking for 24 hrs, @ 5g per water were taken. Results following (Table 32).
Soil application

i) Furadan 3/G: It increased 25% shoot length, 24% root length, 26% shoot weight; 25% root weight and reduced 40% nematode population in *A. nilotica* seedlings. It increased 35% shoot and root lengths and shoot weight; 36% root weight and decreased 45% plant-parasitic nematode populations in *A. alebbek* seedlings. A 30% and 31% increase in shoot and root lengths and 30% increase in shoot and root weight were recorded in *L. leucocephala* seedlings which there by resulted in 47% decrease in plant-parasitic nematodes populations.

ii) Azabin: It increased 20% shoot length; 21% root length; 22% shoot weight; 21% root weight, and reduced 30% plant-parasitic nematodes in *A. cacia nilotica* seedlings. It increased 25% shoot and root lengths, shoot weight and 24% root weight and decreased 35% plant-parasitic nematode populations in case of *Albizzia lebek* seedlings. A 22% shoot length and 23% root length, 24% shoot weight and 23% root weight increase were observed with a 35% reduction in plant-parasitic nematodes in case of *L. leucocephala* seedlings.

Seed soaking

i) Furadan 3/G: 24% and 22% increase in shoot and root lengths and 25% and 23% increase in shoot and root weights with a 35% reduction in plant-parasitic nematodes were recorded in *Acacia nilotica* seedlings. A 33% increase in length and weight of shoot and 34% in length and weight of root were recorded with a decrease of 36% plant-parasitic nematodes in *Albizzia lebek* seedlings. In case of *L. leucocephala* seedlings 28% increase in length and weight of shoot and 30% to 29% increase in length and weight of root were recorded. It reduced plant-parasitic nematodes by 42%.

ii) Azabin: 18% increase in shoot length, and 20% increase in root length, shoot and root weights were observed as a result of 30% reduction in the population of plant-parasitic nematodes in case of *A. cacia nilotica* seedlings. A 24% increase in shoot and root lengths; 25% and 23% increase in shoot and root weights; and 30% reduction in plant-parasitic nematodes were recorded in *Albizzia lebek* seedlings. In case of *L. leucocephala* seedlings it increased 20% shoot and root weights and reduced 30% plant-parasitic nematodes.

Seed soaking in Azbin @ 10 ml per water for 24 hrs. gave significant increase in the seedling vigour of *A. cacia nilotica, Albizzia lebek* and *L. leucocephala*. This treatment reduced nematode population significantly but less in comparison to Furadan 3G.
Table 31. Decrease in nematode populations due to burning after harvest in natural grassland.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Summer (June to December)</th>
<th>Winter (January to May)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Average)</td>
<td>(Average)</td>
</tr>
<tr>
<td>Y₁N</td>
<td>750 (-50)</td>
<td>300 (-70)</td>
</tr>
<tr>
<td>Y₁NO</td>
<td>525 (-65)</td>
<td>200 (-80)</td>
</tr>
<tr>
<td>Y₂N</td>
<td>825 (-45)</td>
<td>300 (-70)</td>
</tr>
<tr>
<td>Y₂NO</td>
<td>675 (-55)</td>
<td>140 (-66)</td>
</tr>
<tr>
<td>Y₃N</td>
<td>585 (-61)</td>
<td>190 (-81)</td>
</tr>
<tr>
<td>Y₃NO</td>
<td>450 (-70)</td>
<td>100 (-90)</td>
</tr>
<tr>
<td>C</td>
<td>1500 (0)</td>
<td>1000 (0)</td>
</tr>
<tr>
<td>CD 1%</td>
<td>58</td>
<td>30</td>
</tr>
</tbody>
</table>

(Figures in parentheses are % reduction over control. Y₁ - annual, Y₂ - biennial and Y₃ - trinennial burnings, N - fertilized with 40 kg N/ha and NO - unfertilized, C - No burning, No fertilization.)

Table 32. Effect of Azab in treatments for nematode management in tree seedlings.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Shoot Length (cm)</th>
<th>Shoot Weight (gm)</th>
<th>Root Length (cm)</th>
<th>Root Weight (gm)</th>
<th>Nematodes Per 100 MI soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia nilotica</td>
<td>82.0</td>
<td>6.5</td>
<td>21.0</td>
<td>7.0</td>
<td>700</td>
</tr>
<tr>
<td>FS</td>
<td>102.5</td>
<td>8.2</td>
<td>26.0</td>
<td>8.8</td>
<td>425</td>
</tr>
<tr>
<td>FSK</td>
<td>102.0</td>
<td>8.2</td>
<td>26.0</td>
<td>8.6</td>
<td>455</td>
</tr>
<tr>
<td>AS</td>
<td>98.0</td>
<td>8.0</td>
<td>25.0</td>
<td>8.5</td>
<td>490</td>
</tr>
<tr>
<td>ASK</td>
<td>97.0</td>
<td>8.0</td>
<td>25.0</td>
<td>8.4</td>
<td>490</td>
</tr>
<tr>
<td>CD 5%</td>
<td>0.6</td>
<td>0.13</td>
<td>0.5</td>
<td>0.06</td>
<td>38</td>
</tr>
<tr>
<td>Albizia lebek</td>
<td>35.5</td>
<td>8.0</td>
<td>20.8</td>
<td>8.0</td>
<td>900</td>
</tr>
<tr>
<td>FS</td>
<td>48.0</td>
<td>10.8</td>
<td>28.0</td>
<td>10.9</td>
<td>495</td>
</tr>
<tr>
<td>FSK</td>
<td>47.0</td>
<td>10.6</td>
<td>27.8</td>
<td>10.7</td>
<td>576</td>
</tr>
<tr>
<td>AS</td>
<td>44.0</td>
<td>10.0</td>
<td>26.0</td>
<td>9.9</td>
<td>595</td>
</tr>
<tr>
<td>ASK</td>
<td>44.0</td>
<td>10.0</td>
<td>25.7</td>
<td>9.8</td>
<td>630</td>
</tr>
<tr>
<td>CD 5%</td>
<td>0.3</td>
<td>0.2</td>
<td>0.13</td>
<td>0.2</td>
<td>50</td>
</tr>
<tr>
<td>Leucaena leucocephala</td>
<td>95.0</td>
<td>9.6</td>
<td>30.0</td>
<td>4.0</td>
<td>1000</td>
</tr>
<tr>
<td>FS</td>
<td>123.5</td>
<td>12.5</td>
<td>39.5</td>
<td>5.0</td>
<td>530</td>
</tr>
<tr>
<td>FSK</td>
<td>121.6</td>
<td>12.0</td>
<td>39.0</td>
<td>5.0</td>
<td>580</td>
</tr>
<tr>
<td>AS</td>
<td>116.0</td>
<td>12.0</td>
<td>37.0</td>
<td>5.0</td>
<td>650</td>
</tr>
<tr>
<td>ASK</td>
<td>114.0</td>
<td>12.0</td>
<td>36.0</td>
<td>4.8</td>
<td>700</td>
</tr>
<tr>
<td>CD 5%</td>
<td>0.7</td>
<td>0.51</td>
<td>0.35</td>
<td>0.18</td>
<td>40</td>
</tr>
</tbody>
</table>

F-Furadan 3G, A- Azabin, S- Soil application, SK- Seed soaking.
DIVISION OF PLANT PHYSIOLOGY AND BIOCHEMISTRY

PPB-1: PHYSIOLOGICAL STUDIES IN FORAGE CROP IMPROVEMENT

1.1 Varietal screening for drought tolerance in oat

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

In general dry matter yield and leaf area index were affected adversely in stress condition but the effect was more in JHO - 888. In all the genotypes the rate of photosynthesis, stomatal conductance and chlorophyll accumulation were decreased while leaf temperature, diffusion resistance and specific leaf weight ratio (Table 33) increased under stress condition.

The higher drought index was recorded in JHO-884 under stress condition which is due to high dry matter accumulation. One irrigation given at jointing stage reduced only 3 per cent dry matter yield in JHO-884 and 15 to 25 percent in other genotypes whereas, two irrigation at tillering and jointing stage reduced 1-2 percent dry matter yield in JHO-884 and 886 and 8 to 10 percent in 889 and 888 as compared to control. Two irrigation at tillering and jointing stage caitained the soil moisture at more than 8% throughout the growth period of crops. Beyond this moisture level, there is sharp reduction in all physiological processes but JHO- 884 and 884 genotypes have the tolerance potential upto 5.0 percent soil moisture. Therefore, the oat genotypes was setected as drought to lerant genolype followed by JHO-886. The RWC, CSI, stomatal conductance, diffusion resistance, PN/TR ratio were found to be the most critical parameters for identification of drought to lerant genotypes in oats.

1.2 Sodicity tolerance in marvel grass, Rhodes grass, sorghum and Oat

(O.P.S. Verma)

Marvel grass (*Dicanthium annuatum*) and Rhodes grass (*Chloris gayana*)

An increase in dry matter yield was recorded at moderate soil sodicity in both grasses. Marvel grass could not survive beyond soil pH 9.2. Rhodes grass survived at pH 9.4 and dry matter yield per pot was at par with sodicity levels of pH 8.9 and 9.2 (Table 34). Growth of grasses over two years decreased the average soil pH to 7.8,
Water soluble sugars increased from 1.94 to 3.22 percent in marvel grass with increase in soil sodicity. However increase in sugar content in Rhodes grass was recorded only at pH 9.2. Sodium content increased and potassium content decreased with increasing soil sodicity in both grasses. Higher content of Na and lower content of water soluble sugars in Rhodes grass indicate that sodium might be an important component, of the osmotic adjustment enabling Rhodes grass to tolerate higher soil sodicity.

**Sorghum**: The plant dry matter increased at moderate soil pH 8.7 in all the improved lines of sorghum with exception to line HD-2 were dry matter decreased with increasing soil pH. Maximum reduction of 72.7 per cent in HD-2 and minimum reduction of 10 percent of dry matter in J-sel-11 was recorded at soil pH 9.3. Water soluble sugar content increased with increasing sodicity levels (Table 35). However, except HD-8 and J-sel-4 other line suffered 50 per cent reduction in dry matter at soil pH 9.3 to control.

**Oat**: Plant height, tiller numbers and dry matter yield per plant increased at pH 8.7 and then decreased with increasing sodicity levels. All the fifteen of the lines could survive beyond 70 days at pH 9.3. With exception to Black nip derivatives, no other lines suffered more than 50 per cent reduction in dry matter yield/plant at pH 9.1 up to 70 days of growth period. However, with increase in temperature in the month of February rapid senescence and drying of leaves was noticed in all the lines at pH 9.1 was found to be the most tolerant among above mentioned lines.

### 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)

Variation in canopy temperature (CT), CT-AT global solar radiation (Rs) and photosynthetically active radiation (PAR) under tree canopies of *Luecaena leucocephala* and *Acacia tortilis* and in open field are shown in table-36. The difference in canopy air temperature (CT-AT) was recorded -4.1 °C and -2.5°C in *L. leucocephala* and *A. tortilis* respectively. The light transmission under tree canopies was recorded 28-32 percent in *L. leucocephala* and 52-60 percent in *A. tortilis*. The leaf temperature of *C. ciliaris* and *P. maximum* were lower under tree canopies as compared to the grasses grown in open field. There was greater reduction in transpiration rate (TR) in both the grass species under tree canopies of
L. leuocepha/a which may be due to low availability of PAR and higher diffusion resistance of leaf.

The maximum rate of photosynthesis (PN) was recorded 39.29 and 34.91/µ mole/m²/S in Cenchrus ciliaris and Panicum maximum in open field but this rate was reduced sharply under the tree canopies. No significant differences were observed between the two grass species with respect to their rate of photosynthesis under the tree canopies. Similar to the rate of photosynthesis, stomatal conductance, PN/Cl, PN/COND and PN/TR ratio decreased significantly in both the grass species under tree canopies. The internal cellular CO₂, the PN/COND and PN/TR indicates the intrinsic water use efficiency in these grasses. The reduction in these physiological characters under tree canopies might be due to decrease in PAR causing partial closure of stomatal pore occurred through which stomatal conductance decreases. The highly significant correlations of these parameters with PAR is suggestive of the fact that these physiological activities are mainly influenced by this micro-environmental parameters. Dry matter production was reduced by 21 percent in C. ciliaris and 43 percent in P. maximum under tree canopies of L. leucocepha/a relative to the pure grasses grown in open field. C. ciliaris accumulate more Chl-b, dry matter and specific leaf mass under tree canopies than P. maximum, indicating more suitability for silvipastoral system in semi-arid region.

**PPB-2: BIOCHEMICAL STUDIES OF FORAGE CROPS**

**2.1 Biochemical response of Brachiaria species to flooding/waterlogging**

(Sewa Ram)

Two grass species namely Brachiaria mutica (tolerant) and B. brizantha (intolerant) studied for their biochemical response to flooding. Sucrose synthase activity was unaffected in B. mutica roots and declined in B. brizantha roots. Acid invertase activity increased in B. mutica root under flooding where as it decreased in B. brizantha roots. Alkaline invertase activity remained unaffected in both the species. Sucrose phosphate synthase activity increased slightly in B. mutica roots and remained unaffected in B. brizantha roots under flooding. Reducing sugars increased in B. mutica roots and decreased in B. brizantha roots during flooding (Table 37).
Ethanol level was several times more in *B. mutica* roots and leaves in comparison to *B. brizantha* roots and leaves respectively. Ethanol concentration did not change during flooding in both the species. ADH activity increased four fold in *B. mutica* roots during flooding and remained unaffected in *B. brizantha*. Tolerance to higher concentration of ethanol and higher ADH activity in *B. mutica* roots during flooding would allow for the maintenance of ethanol fermentation system and result in continued energy production. MDH levels increased six fold in *B. mutica* root and decreased to half in leaves during flooding and remained unchanged in *B. brizantha*. Malic enzyme showed similar pattern in both the species indicating that ME may not be a significant factor in determining flooding tolerance. The study indicated that increased ADH and MDH activity play a central role in metabolic adaptation to flooding stress.

**Table - 33. Dry matter yield and drought index at specific weight and leaf area index 50% flowering stage in oat genotypes**

<table>
<thead>
<tr>
<th>Genotypes</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>T6</th>
<th>T7</th>
</tr>
</thead>
<tbody>
<tr>
<td>JHO-884</td>
<td>798</td>
<td>884</td>
<td>972</td>
<td>919</td>
<td>978</td>
<td>980</td>
<td>998</td>
</tr>
<tr>
<td>886</td>
<td>763</td>
<td>886</td>
<td>927</td>
<td>906</td>
<td>1080</td>
<td>1081</td>
<td>1088</td>
</tr>
<tr>
<td>888</td>
<td>569</td>
<td>768</td>
<td>793</td>
<td>689</td>
<td>889</td>
<td>970</td>
<td>988</td>
</tr>
<tr>
<td>889</td>
<td>569</td>
<td>768</td>
<td>793</td>
<td>689</td>
<td>889</td>
<td>970</td>
<td>988</td>
</tr>
<tr>
<td></td>
<td>0.80</td>
<td>0.88</td>
<td>0.97</td>
<td>0.92</td>
<td>0.98</td>
<td>0.98</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>0.72</td>
<td>0.81</td>
<td>0.85</td>
<td>0.83</td>
<td>0.99</td>
<td>0.99</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>0.57</td>
<td>0.77</td>
<td>0.80</td>
<td>0.70</td>
<td>0.90</td>
<td>0.98</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>0.85</td>
<td>0.74</td>
<td>0.75</td>
<td>0.73</td>
<td>0.92</td>
<td>0.94</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**Specific weight and leaf area index in oat genotypes at 50% flowering stage**

<table>
<thead>
<tr>
<th>Genotypes</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>T6</th>
<th>T7</th>
</tr>
</thead>
<tbody>
<tr>
<td>JHO-884</td>
<td>5.51</td>
<td>5.68</td>
<td>5.72</td>
<td>5.32</td>
<td>5.28</td>
<td>5.44</td>
<td>5.55</td>
</tr>
<tr>
<td>886</td>
<td>5.35</td>
<td>5.54</td>
<td>5.74</td>
<td>4.74</td>
<td>5.12</td>
<td>5.46</td>
<td>5.21</td>
</tr>
<tr>
<td>888</td>
<td>4.61</td>
<td>4.65</td>
<td>5.07</td>
<td>4.69</td>
<td>4.75</td>
<td>5.65</td>
<td>5.70</td>
</tr>
<tr>
<td>889</td>
<td>4.65</td>
<td>4.68</td>
<td>5.44</td>
<td>5.28</td>
<td>5.13</td>
<td>5.10</td>
<td>5.05</td>
</tr>
<tr>
<td>3.33</td>
<td>4.26</td>
<td>4.41</td>
<td>4.41</td>
<td>4.33</td>
<td>4.92</td>
<td>5.72</td>
<td>6.25</td>
</tr>
<tr>
<td></td>
<td>3.52</td>
<td>4.42</td>
<td>4.38</td>
<td>4.44</td>
<td>5.08</td>
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<td></td>
<td>2.86</td>
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<td>3.97</td>
<td>3.70</td>
<td>4.19</td>
<td>5.66</td>
<td>6.63</td>
</tr>
<tr>
<td></td>
<td>3.32</td>
<td>4.28</td>
<td>4.32</td>
<td>3.96</td>
<td>4.91</td>
<td>5.68</td>
<td>6.91</td>
</tr>
</tbody>
</table>

*T1 = Irrigation at sowing time, T2 = T1 + Irrigation at tillering stage, T3 = T1 + Irrigation at jointing stage 1, T4 = T1 + Irrigation at flowering initiation stage, T5 = T1 + T2 + T3, T6 = T1 + T2 + T3 + T4, T7 = T1 + T2 + T3 + T4 + Irrigation at 50% flowering stage.*
### Table 34. Effect of sodicity levels on dry matter yield and water soluble sugar of grasses

<table>
<thead>
<tr>
<th>Grasses</th>
<th>Dry matter yield (g/pot)</th>
<th>Water soluble sugar (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soil pH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.8 8.7 9.0 9.3</td>
<td>7.8 8.7 9.0 9.3</td>
</tr>
<tr>
<td><strong>Dicanthium annulatum</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IGFRI-1978</td>
<td>42.0 42.6 37.3</td>
<td>2.78 2.83 3.10</td>
</tr>
<tr>
<td>IGFRI-1994</td>
<td>40.1 45.6 37.0</td>
<td>2.05 2.46 3.22</td>
</tr>
<tr>
<td>IGFRI-1981</td>
<td>39.0 40.5 38.0</td>
<td>1.94 2.78 2.94</td>
</tr>
<tr>
<td>IGFRI-19B</td>
<td>44.0 46.6 -</td>
<td>2.42 3.22 -</td>
</tr>
<tr>
<td>IGFRI-19A</td>
<td>46.3 47.0 -</td>
<td>2.13 2.71 -</td>
</tr>
<tr>
<td><strong>Chloris Gayana</strong></td>
<td>35.0 40.0 40.5 40.5</td>
<td>1.72 1.75 1.76 2.10</td>
</tr>
</tbody>
</table>

### Table 35. Effect of sodicity levels on dry matter yield and water soluble sugar of improved lines of sorghum.

<table>
<thead>
<tr>
<th>Improved lines</th>
<th>Dry matter yield (g/plant)</th>
<th>Water soluble sugar (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soil pH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.6 8.7 9.1 9.3</td>
<td>7.6 8.7 9.1 9.3</td>
</tr>
<tr>
<td>HD-8</td>
<td>55.0 34.6 34.6 15.0</td>
<td>2.35 2.46 4.84 6.88</td>
</tr>
<tr>
<td>HD-2-1</td>
<td>55.3 56.3 41.3 37.3</td>
<td>2.47 2.56 2.66 4.71</td>
</tr>
<tr>
<td>J. Sel-10</td>
<td>53.3 55.6 47.3 29.0</td>
<td>2.25 3.10 4.19 5.27</td>
</tr>
<tr>
<td>J. Sel-6</td>
<td>43.0 44.6 31.3 30.6</td>
<td>2.15 2.55 2.99 3.53</td>
</tr>
<tr>
<td>J. Sel-11</td>
<td>42.6 44.6 42.6 38.3</td>
<td>2.06 3.10 3.73 4.42</td>
</tr>
<tr>
<td>HD-10</td>
<td>39.0 41.6 33.3 24.0</td>
<td>2.06 2.47 3.45 5.41</td>
</tr>
<tr>
<td>S-9</td>
<td>60.3 62.6 52.0 38.6</td>
<td>1.96 2.25 3.10 3.45</td>
</tr>
<tr>
<td>J. Sel-4</td>
<td>50.3 47.6 32.6 22.3</td>
<td>2.15 2.53 4.10 4.71</td>
</tr>
</tbody>
</table>
Table 36. Variations in physiological characters in grasses under tree canopies and in open field condition.

<table>
<thead>
<tr>
<th>Canopy</th>
<th>PAR $\mu$mole/$m^2/s$</th>
<th>CT-AT $^\circ$C</th>
<th>PN $\mu$mole/$m^2/s$</th>
<th>CS (sec$^{-1}$)</th>
<th>TR (Ug/cm$^2$/s)</th>
<th>DR (cm$^{-1}$)</th>
<th>LT $oc$ (mgC$_2$ / gH$_2$O)</th>
<th>PN/TR (mgC$_2$ / gH$_2$O)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Panicum maximum</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open</td>
<td>1830</td>
<td>-</td>
<td>34.91</td>
<td>1.19</td>
<td>7.48</td>
<td>2.33</td>
<td>34.56</td>
<td>20.54</td>
</tr>
<tr>
<td>L. leucoccephala</td>
<td>590</td>
<td>-4.1</td>
<td>12.59</td>
<td>0.70</td>
<td>4.83</td>
<td>3.42</td>
<td>31.36</td>
<td>11.87</td>
</tr>
<tr>
<td>A. tortilis</td>
<td>970</td>
<td>-2.6</td>
<td>17.65</td>
<td>0.87</td>
<td>4.92</td>
<td>3.06</td>
<td>33.40</td>
<td>15.79</td>
</tr>
<tr>
<td><em>Cenchrus ciliaris</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open</td>
<td>1830</td>
<td>-</td>
<td>39.29</td>
<td>1.21</td>
<td>7.81</td>
<td>2.29</td>
<td>34.48</td>
<td>22.13</td>
</tr>
<tr>
<td>L. leucoccephala</td>
<td>600</td>
<td>-4.0</td>
<td>11.15</td>
<td>0.62</td>
<td>4.13</td>
<td>3.37</td>
<td>32.58</td>
<td>11.47</td>
</tr>
<tr>
<td>A. tortilis</td>
<td>995</td>
<td>-2.3</td>
<td>16.96</td>
<td>0.75</td>
<td>4.56</td>
<td>3.15</td>
<td>32.90</td>
<td>16.38</td>
</tr>
</tbody>
</table>

Table 37. ADH, MDH and ME activities and alcohol content in roots and leaves of *B.* mutica and *B.* brazantha (mM/gFW/M)

<table>
<thead>
<tr>
<th></th>
<th>ADH N</th>
<th>F</th>
<th>MDH N</th>
<th>F</th>
<th>ME N</th>
<th>F</th>
<th>Alcohol Content</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>B.</em> mutica</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root</td>
<td>0.46</td>
<td>1.56</td>
<td>0.05</td>
<td>0.34</td>
<td>0.06</td>
<td>0.12</td>
<td>0.825</td>
</tr>
<tr>
<td>Leaf</td>
<td>0.16</td>
<td>0.16</td>
<td>0.90</td>
<td>0.68</td>
<td>0.12</td>
<td>0.04</td>
<td>0.225</td>
</tr>
<tr>
<td><em>B.</em> brazantha</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root</td>
<td>0.12</td>
<td>0.16</td>
<td>0.04</td>
<td>0.05</td>
<td>0.06</td>
<td>0.12</td>
<td>0.025</td>
</tr>
<tr>
<td>Leaf</td>
<td>0.04</td>
<td>0.03</td>
<td>0.56</td>
<td>0.56</td>
<td>0.12</td>
<td>0.06</td>
<td>0.002</td>
</tr>
</tbody>
</table>

N= Normal  F= Flooded
DIVISION OF AGRICULTURAL ENGINEERING AND
POST HARVEST TECHNOLOGY

A E 1.1 : Development of forage harvesting machine

(P.S. Chatopadhayay and P.D. Gupta)

The IGFRI Flail Mower was tested on fodder sorghum (M.P. Chari). The average cutting height of the crop, plant population and soil moisture were 17.1 cm, 17/m² and 11.4% respectively.

The performance of the machine of harvesting sorghum was quite satisfactory (Table 38). The average field capacity and field efficiency were 0.163 ha/h and 66.3 respectively. The overall cost of operation for chaffed material was comparatively (Rs 703/ha) than the corresponding cost of sickle harvesting (Rs. 1225/ha) unchaffed material. The machine is recommended for harvesting fodder sorghum for fresh feeding and silage making. Prototype of the same machine was sent to Central Research Institute for Goats, Farah, Mathura and other one to Central Sheep and Wool Farm, Rishikesh, Dehradun for testing and evaluation.

The IGFRI Rotary Disc Mover was evaluated on large scale for berseem harvesting. Bunds were laid out at 14 m x 7 m and the height of bunds were adjusted between 15 to 20 cm. Four cuts of the crop were taken by machine. Beside, 2 ha of berseem crop was harvested in the farm at other sites. The performance of the machine was satisfactory and recommended for harvesting fodder crop.

Table 38. Performance and cost analysis of IGFRI Flail Mower on harvesting fodder Sorghum

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particulars</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Area of harvest</td>
<td>1.0</td>
</tr>
<tr>
<td>2.</td>
<td>Effective field capacity ha/h</td>
<td>0.163</td>
</tr>
<tr>
<td>3.</td>
<td>Field efficiency, %</td>
<td>66.3</td>
</tr>
<tr>
<td>4.</td>
<td>Yield of crop, t/ha</td>
<td>20.13</td>
</tr>
<tr>
<td>5.</td>
<td>Green matter yield, t/ha</td>
<td>34.83</td>
</tr>
<tr>
<td>6.</td>
<td>Dry matter yield, t/ha</td>
<td>6.99</td>
</tr>
<tr>
<td>7.</td>
<td>Cost of machine operation, Rs/h</td>
<td>100</td>
</tr>
<tr>
<td>8.</td>
<td>Cost of labour for unloading the trailer, Rs/ha</td>
<td>90</td>
</tr>
<tr>
<td>9.</td>
<td>Overall cost of harvest, Rs/ha</td>
<td>702.70</td>
</tr>
<tr>
<td>10.</td>
<td>Unit cost of harvest, Rs/t</td>
<td>34.94</td>
</tr>
<tr>
<td>11.</td>
<td>Unit cost of harvest, Rs/t dry matter</td>
<td>100.50</td>
</tr>
<tr>
<td>12.</td>
<td>Cost of sickle harvesting Rs/ha</td>
<td>1225</td>
</tr>
</tbody>
</table>

(Rs. 35/- per man-day for 35 man days)
AE 1.2 : Popularization of improved bullock drawn implements among farmers of adopted villages

(P.S. Chattopadhyay, M.B. Tamhankar and Brajesh Singh)

During *kharif* season, field trials for disc harrow and two row bullock drawn seed drill were conducted at Kararl village for black gram, green gram and sesameum (Til). The seed rates were 16.4, 16.1 and 4.1 kg/ha for black gram, green gram and til respectively. The average field capacity of the Seed drill was 0.094 ha/h. The plant population for black gram, green gram and til was 22, 24 and 49, and corresponding yields were 0.39, 0.28 and 0.13 t/ha. The increase in yield by using the package of improved implements over traditional method of cultivation by desi plough was 21.8%, 12.0% and 18.25% for black gram, green gram and til respectively.

During *rabi* season, wheat, gram and mustard crops were sown at Kararl village by using a package of IGFRI implements such as Disc Harrow and IGFRI two row bullock drawn seed drill. The average seed rate maintained was 106.83 and 5.8 kg/ha for wheat, gram and mustard crops respectively. The average yield was recorded as 3.2, 1.25 and 0.58 t/ha for wheat, gram and mustard crops respectively.

In *kharif* eight farmers and in *rabi* season 5 farmers voluntarily used the IGFRI implements for above mentioned crops and expressed their inclination in adopting the implements in forthcoming seasons.

AE 1.3 : Studies on evaluation of tillage equipments for maximization of grass + legume production

(P.D. Gupta and K.C. Kanodia)

The project was continued in fourth years also with existing five treatments in the field. The treatments were No tillage (control) (*T*1), Broadcast of pelleted seed and fertilizer (*T*2), Placing pelleted seed and fertilizer behind tractor drawn cultivator (*T*3), Tractor drawn IGFRI pitterdisc harrow followed by broadcasting of pelleted seed and fertilizer (*T*4), Tractor drawn subsoiler followed by placement of seed and fertilizer behind tractor drawn cultivator (*T*5).

During this year fertilizer @ 30 kgN/ha was applied as top dressing in seed row in case of treatment *T*3 and *T*5 and broadcasted in *T*2 and *T*4 treatment. No difference in moisture percentage was noticed at fortnightly interval among treatments at three depths (15, 30 and 45 cm). The maximum number of tussock in case of *Cenchrus ciliaris* and stylo were 13.2 and 13.4 thousands/ha for *T*5, *T*2 and with minimum 11.3
and 9.1 thousands /ha for both the crops in T5 respectively. The maximum yields of *Cenchrus ciliaris* and stylo were in T4 (5.21 and 0.50 t/ha) and minimum for T2 (2.78 and 0.44 t/ha) (Table 39). The maximum total bio-mass yield was recorded as 7.24 t/ha in case of T4 and minimum 3.06 t/ha for T1.

On the basis of four years study, tilling by tractor drawn pitter discer before seeding increases moisture conservation, plant vigour and yield as compared to other treatments.

Table 39 Influence of tillage treatments on moisture percentage, number of tussocks and productivity of grasslands

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Moisture% (Average of April 93 to March 94)</th>
<th>No of tussocks</th>
<th>Biomass yield (DM) t/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At 15cm Depth</td>
<td>At 30cm Depth</td>
<td>At 45cm Depth</td>
</tr>
<tr>
<td>T1</td>
<td>6.6</td>
<td>7.5</td>
<td>8.3</td>
</tr>
<tr>
<td>T2</td>
<td>6.7</td>
<td>7.6</td>
<td>8.4</td>
</tr>
<tr>
<td>T3</td>
<td>6.7</td>
<td>7.6</td>
<td>8.3</td>
</tr>
<tr>
<td>T4</td>
<td>6.1</td>
<td>7.5</td>
<td>8.3</td>
</tr>
<tr>
<td>T5</td>
<td>6.7</td>
<td>7.6</td>
<td>8.4</td>
</tr>
</tbody>
</table>

A.E-1.4: Development and testing of IGFRI grass seed harvester

(Brajesh Singh And M. B. Tamhakar)

The existing tractor front mounted grass seed harvester (old model) was put to field test under *Cenchrus setigerus* crop at Avikanagar. Performance of the Harvester was unsatisfactory due to (a) Faulty stationary sweeping surface inclination and improper initial height setting of the machine making it non functional at a crop height below 65 cm (b) Abnormally low crop height i.e. 65 to 80 cm due to dry spell. On account of present limitations some modifications such as provision of additional height adjustment mechanism and replacement of existing V-belt pulley by 12" size V-belt pulley were incorporated to bring machine performance at satisfactory level.

Number of arms were increased from 4 to 6 to increase the effectiveness of seed collection mechanism and a casted pulley of 12" size was incorporated in the power transmission mechanism. To avoid passing off of collected seed from seed
box, a cloth was spread over the seed box. This gave the same effect as would have been possible by replacing part of sieve of seed box with MS sheet. The seed collector having aforesaid modifications were tested at C.R. Farm under *Cenchrus ciliaris* + *Cenchrus setigerus* crop. Performance report is given in tables 40 and 41.

Nylon brushes were found more effective for collection of seeds of *Cenchrus setigerus*. In case of *Cenchrus ciliaris* effectiveness of rubberised sweeping surface was better. However, part of nylon brushes were sheded after harvesting operation. Therefore, introduction of nylon brushes proved a partial success.

The modified machine was also tested on Dinanath crop. As the height of Dinanath crop was observed very high (upto 2.25 metre), further modifications were incorporated in the harvestor so that the seed may be harvested from such high level. Suitable links for extending the height of the machine were incorporated and V- belt was suitably replaced. Though the machine was able to collect seed effectively, yet excess vibrations were observed.

Table 40: Performance of modified tractor at Avikanagar

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Crop conditions</th>
<th>Ht. of stationary sweeping surface (cm.)</th>
<th>Area covered (ha)</th>
<th>Time taken (Min.)</th>
<th>Seed collected (kg)</th>
<th>Seed collected (kg/hr)</th>
<th>Seed collected (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <em>Cenchrus setigerus</em></td>
<td>ht: 65-80cm. Seed availability: 40%</td>
<td>45</td>
<td>0.054</td>
<td>12</td>
<td>0.8</td>
<td>4.0</td>
<td>14.8</td>
</tr>
<tr>
<td>2. <em>Cenchrus setigerus and ciliaris</em></td>
<td>ht: 60-70cm. seed availability: 40%</td>
<td>45</td>
<td>0.18</td>
<td>22</td>
<td>2.0</td>
<td>5.4</td>
<td>11.2</td>
</tr>
<tr>
<td>3. <em>Cenchrus setigerus</em></td>
<td>ht: 65-80cm. seed availability: 40%</td>
<td>45</td>
<td>0.10</td>
<td>15</td>
<td>1.9</td>
<td>7.6</td>
<td>19.0</td>
</tr>
<tr>
<td>4. <em>Cenchrus setigerus</em></td>
<td>ht: 60-75cm. seed availability: 10%as the crop was harvested many times</td>
<td>45</td>
<td>0.75</td>
<td>90</td>
<td>2.5</td>
<td>16</td>
<td>3.3</td>
</tr>
</tbody>
</table>
Table 41 Performance of modified tractor front mounted grass seed harvester at C. R. Farm, IGFRI, Jhansi

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Crop conditions</th>
<th>Status of implements</th>
<th>Area covered ha</th>
<th>Time taken min</th>
<th>Seed Seed collected</th>
<th>Seed collected (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Oryza sativa</em> + <em>Cenchrus ciliaris</em></td>
<td>Old V- pully (8&quot; size) + cloth in seed box + six rubber poded &amp; two nylon brushed arms</td>
<td>0.075</td>
<td>10</td>
<td>1.6</td>
<td>9.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sweeping surface Ht: 70 cm.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>-do-</td>
<td>Bigger casted V- pully (12&quot; size) + cloth in seed box + poded arms: Sweeping surface Ht: 70 cm.</td>
<td>0.109</td>
<td>15</td>
<td>3.48</td>
<td>13.9</td>
</tr>
<tr>
<td>3.</td>
<td>Dinanath crop; ht. of crop upto 220 cm; over matured and hand harvested; Seed availability</td>
<td>As in S. N. (2) above; Sweeping Surface Ht.: 135 cm</td>
<td>0.16</td>
<td>20</td>
<td>1.8</td>
<td>5.4</td>
</tr>
</tbody>
</table>

A.E - 2.1.2 Evaluation of feed pelleting machine

(P.D. Gupta, R. K. Goyal and V. C. Pachauri)

The feed pelleting machine was tried for making the feed pellets of different material combination at 10, 15, 20 and 25% (wb) moisture, it was tried with subabool leaves + wheat straw in the ratio of 3:2. The water was sprinkled at the rate of 55%. The loose material fresh density was 300 kg/m³ at the time of putting in hopper. The average moisture content of pelleted material on wet basis was 58.7%. Two sizes of the die 28 mm and 38 mm were used for making the feed pellets.

By using 28 mm diametet er die, the capacity of the machine was found 62.5 kg/hr, fresh and dry matter bulk density of feed pellets were 983.0 kg/m³ and 432.6
kg/m$^3$ respectively, power consumption was 4.25 KWH and unit cost of operation was Rs. 211.20 per ton.

By using 38 mm dia, the capacity of the machine was found 85 kg/hr fresh and dry matter bulk density of feed pellets were 1125 kg/m$^3$ and 495 kg/m$^3$ respectively, power consumption was 5.5 KWH and unit cost of operation was Rs. 183.60 per ton.

The feed pellets of wheat straw + concentrate after grinding in the ratio of 1:2 were tried but was not successful which might be due to coarse grinding. Further attempt shall be on finely ground concentrate mixture.
1.6 Impact of integrated development of Lakara- Karari watershed on rural economics

(R.A. Singh)

Land distribution and cropping intensity

The land distribution of Karari village showed no significant change for big, upper medium and lower medium farmers from 1986-87 to 1993-94. The area for above categories of farmers was 68.37, 71.99 and 338.36 ha, respectively. However, the area under cultivation of small and marginal land holders increased by 14.76 and 10.44 percent, respectively as compared to 1986-87. The overall irrigation intensity of the village increased from 47.83% to 69.36% due to increase in the number of wells.

The cropping intensity varied from 98.84 percent for big category to 126.49 percent for small category of farmers.

Area production and productivity of different crops in village Karari

Major crops grown in Karari village were wheat, wheat + mustard, barley, gram, gram + oilseed, mustard, masoor, berseem and sehuwan during the rabi 1992-93. The area, production and use of seed-fertilizer of major crops are given in table 42.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area (ha)</th>
<th>Production Main (Tonne)</th>
<th>Crop Area (ha)</th>
<th>Production Main (Tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>269.27</td>
<td>628.01</td>
<td>Wheat</td>
<td>269.27</td>
</tr>
<tr>
<td></td>
<td>(1.0)</td>
<td>(2.33)</td>
<td></td>
<td>(2.33)</td>
</tr>
<tr>
<td>Wheat + Mustard</td>
<td>145.14</td>
<td>419.70</td>
<td>Wheat + Mustard</td>
<td>419.70</td>
</tr>
<tr>
<td></td>
<td>(1.0)</td>
<td>(2.89)</td>
<td></td>
<td>(2.89)</td>
</tr>
<tr>
<td>Barley</td>
<td>20.66</td>
<td>55.20</td>
<td>Barley</td>
<td>55.20</td>
</tr>
<tr>
<td></td>
<td>(2.67)</td>
<td>(0.06)</td>
<td></td>
<td>(0.06)</td>
</tr>
<tr>
<td>Gram</td>
<td>31.68</td>
<td>21.68</td>
<td>Gram</td>
<td>21.68</td>
</tr>
<tr>
<td></td>
<td>(0.69)</td>
<td>(0.52)</td>
<td></td>
<td>(0.52)</td>
</tr>
<tr>
<td>Gram + Oilseed</td>
<td>13.27</td>
<td>2.08</td>
<td>Gram + Oilseed</td>
<td>2.08</td>
</tr>
<tr>
<td></td>
<td>(0.69)</td>
<td>(0.11)</td>
<td></td>
<td>(0.11)</td>
</tr>
<tr>
<td>Lentil</td>
<td>0.63</td>
<td>0.536</td>
<td>Lentil</td>
<td>0.536</td>
</tr>
<tr>
<td></td>
<td>(0.85)</td>
<td>(0.55)</td>
<td></td>
<td>(0.55)</td>
</tr>
<tr>
<td>Mustard</td>
<td>7.936</td>
<td>5.25</td>
<td>Mustard</td>
<td>5.25</td>
</tr>
<tr>
<td></td>
<td>(0.86)</td>
<td>(1.07)</td>
<td></td>
<td>(1.07)</td>
</tr>
<tr>
<td>Swam</td>
<td>0.84</td>
<td>0.46</td>
<td>Swam</td>
<td>0.46</td>
</tr>
<tr>
<td></td>
<td>(0.56)</td>
<td>(0.27)</td>
<td></td>
<td>(0.27)</td>
</tr>
<tr>
<td>Berseem</td>
<td>12.224</td>
<td>669.95</td>
<td>Berseem</td>
<td>669.95</td>
</tr>
<tr>
<td></td>
<td>(54.76)</td>
<td>(43.12)</td>
<td></td>
<td>(43.12)</td>
</tr>
</tbody>
</table>

Figures in parenthesis are in ha.
2.1 Studies on sampling in forage crops for evaluating the optimum sample size for yield estimation

(Ashok Kumar and D.P. Handa)

1. Plot sampling technique in *Stylosanthes* for technology validation experiments

For estimating yield of *Stylosanthes* under uniform condition at Jhansi, it was found that at 5 percent error, sample sizes of plot shape in 1 mx 1 m, 2 m x 1 m, 3 m x 1 m and 4 m x 1 m elongated in N-S direction were 129, 76, 60, and 50 covering 9.94, 11.71, 13.79 and 15.4 percent sampled area of the population (1296 /m²), respectively (Table 43), where as at 10 percent errors these were 35, 21, 17 and 14 each covering 2.69, 3.21, 3.85 and 4.35 percent sampled area respectively.

Considering time/ labour/precision, 76 plots of size 2 m² with shape 2 m x 1 m (N-S) each selected with Simple Random Sampling without replacement, covering 11.71 percent sampled area was found appropriate for yield estimation of Stylosanthes.

Table 43. Percent area to be sampled for yield estimation of stylosanthes (based on desired variation as a % of P, P° mean.)

<table>
<thead>
<tr>
<th>Variatom</th>
<th>1m²</th>
<th>2m²</th>
<th>3m²</th>
<th>4m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square</td>
<td>Long N-S</td>
<td>Long E-W</td>
<td>Long N-S</td>
<td>Long E-W</td>
</tr>
<tr>
<td>Plot sharp</td>
<td>1m x 1m</td>
<td>2m x 1m</td>
<td>1m x 2m</td>
<td>3m x 1m</td>
</tr>
<tr>
<td>5%</td>
<td>9.94</td>
<td>11.71</td>
<td>13.97</td>
<td>17.52</td>
</tr>
<tr>
<td>(129)</td>
<td>(76)</td>
<td>(91)</td>
<td>(60)</td>
<td>(76)</td>
</tr>
<tr>
<td>10%</td>
<td>2.69</td>
<td>3.21</td>
<td>3.85</td>
<td>5.04</td>
</tr>
<tr>
<td>(35)</td>
<td>(21)</td>
<td>(25)</td>
<td>(17)</td>
<td>(22)</td>
</tr>
<tr>
<td>15%</td>
<td>1.21</td>
<td>1.45</td>
<td>1.77</td>
<td>2.31</td>
</tr>
<tr>
<td>(18)</td>
<td>(9)</td>
<td>(11)</td>
<td>(8)</td>
<td>(10)</td>
</tr>
<tr>
<td>20%</td>
<td>0.68</td>
<td>0.82</td>
<td>1.00</td>
<td>0.99</td>
</tr>
<tr>
<td>(9)</td>
<td>(5)</td>
<td>(7)</td>
<td>(4)</td>
<td>(6)</td>
</tr>
<tr>
<td>25%</td>
<td>0.44</td>
<td>0.53</td>
<td>0.65</td>
<td>0.64</td>
</tr>
<tr>
<td>(6)</td>
<td>(3)</td>
<td>(4)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>30%</td>
<td>0.31</td>
<td>0.37</td>
<td>0.45</td>
<td>0.44</td>
</tr>
<tr>
<td>(4)</td>
<td>(2)</td>
<td>(3)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
</tbody>
</table>

Figures in parenthesis are approximate number of units to be sampled for the corresponding size and shape of plots.

For predicting percent area to be sampled in the units of 2m x1m shape of plots, a Logrithmic prediction equation is found suitable at 5 percent sampling error as a percent of mean which is depicted graphically. The equation is as follows:
\[ \ln Y = 4.98803 - 1.74897 \ln X \]

\[(0.05522) \quad R^2 = 0.98818\]

where \( Y \) = Percent sampled area and \( X \) = Percent error

**REB 2.2: STATISTICAL STUDIES ON RAINFALL PATTERN OF BUNDELKHAND**

### 2.2.1 Rainfall studies

(D. P. Handa)

The data of 32 years (1961-1992) were analysed and some of the important observations are:

The average rainfall was 949.56 mm with variability of 26.17%. Most of the rainfall was received during the four months i.e. June - Sept, accounting for 90.78% of the total rainfall of the year. The maximum amount of rainfall 728.6 mm was recorded in August, 1980.

Rainfall during Jan- May and Nov-Dec. was always less than 50mm during the period.

July and August were the heaviest rainfall months when the rainfall was more than 300 mm accounting for 47.53% of the total rainfall, while September accounted for 15% of the years rainfall.

54.17% were found to be the drought months, 33.33% were normal and 12.5% were above normal. October to May had more than 50% drought months and low rainfall. Suggesting a necessity for water storage conservation and economical use of water during these months.

The amount of rainfall with 50% probability of occurrence during June, July, August and September was worked out to be 78, 293, 278 and 135 mm, respectively.

The probability of occurrence of drought during June, July, August and September turned out to be 0.375, 0.125, 0.187 and 0.344 respectively which resulted into mean recurrence of drought at the interval of 2.66, 8.00, 5.33, and 290 years, respectively.

The rainfall for the month of June, July and August indicated normal distribution while September showed abnormal distribution.

### 2.2.2 Crop weather relationship studies

(D. P. Handa and Ashok Kumar)
M.P. Chari: This crop covers about 75-80 days from first week of July to mid Sept. This period is divided into 11 weeks which can be grouped into three phases.

1. Establishment phase
   week No 27-31

2. Vegetative phase
   week No 32-35

3. Maturity phase
   week No 36-37

The average daily maximum and minimum temperature varied from 23.98 to 38.15°C and 17 to 26.27°C respectively. The mean temperature varied from 20.53 to 32.21 °C while mean humidity ranged between 52 to 78 % during the crop period.

It was found that the maximum and minimum temperature had positive effect during the establishment phase and humidity and rainfall had significant positive effect during vegetative phase. However, weather parameters appeared to have no significant effect during the maturity phase.

Weighted Analysis

Here the effect of change in weather variable as on yield in week as a linear function of respective correlation coefficients between yield and weather variable were analysed.

1. Maximum Temperature:
   \[ Y = 16.83 - 0.73Z_0 + 3.19Z_1 + 5.18Z_2 + 16.36T \]  \( R^2 = 0.70 \)

2. Minimum Temperature:
   \[ Y = 234.14 + 0.74Z_0 - 5.28Z_1 - 14.66Z_2 + 18.28T \]  \( R^2 = 0.54 \)

3. Average Humidity:
   \[ Y = 111.90 + 0.12Z_0 - 4.05Z_1 - 3.67Z_2 + 11.05T \]  \( R^2 = 0.71 \)

4. Rainfall:
   \[ Y = 80.04 - 0.13Z_0 + 0.19Z_1 + 0.48Z_2 + 17.70T \]  \( R^2 = 0.73 \)

5. Mean Temperature:
   \[ Y = 78.09 - 1.74Z_0 + 21.68Z_1 + 39.80Z_2 + 16.39T \]  \( R^2 = 0.73 \)

Where

\[ Z_0 = \sum_{w=1}^{n} X_w, \quad Z_1 = \sum_{w=1}^{n} r \times y(w), \quad X_w, \]
\[ Z_2 = \sum_{w=1}^{n} r^2 \times y(w), \quad X_w \]

and \( T = \) rand variable
The proportionate change in yield with respect to proportionate change in weather variables during different growth stages of the crop can be determined from the above equations.

**Berseem**: The average maximum temperature varied from 28.16 to 31.95°C and minimum temperature varied from 8.92 to 14.08°C. Mean humidity varied between 36.61 to 58.55% during the crop period. The crop covers about 164 days (42th to 18th week) from October to April.

Step regression technique indicated that the mean temperature and rainy days had significant role in the production of berseem.

**Oats**: The crop period covers from 45th to 11th week (105 days). Total period was divided into three stages.

1. Growth stage
2. Tillering and jointing stage
3. Boot stage

The maximum temperature varied from 18.10 to 32.00°C, minimum temperature 2.10 to 15.87°C and humidity 43.38 to 65.80% during the crop period.

Number of rainy days during growth stage, amount of rainfall during tillering stage and mean temperature during boot stage showed significant effect on the crop.
DIVISION OF EXTENSION AND TRAINING

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

1.5 Role of women in agriculture specially forage crops under integrated development of Lakara-Karari watershed

(Manju Suman)

The role of women was found in weeding, gap filling, irrigation, harvesting, chaffing of forage crops, cleaning of animal shed and milking.

1.6 Training needs of farmers in forage crops

(Maharaj Singh)

Majority of small, medium and large farmers need training on Agroforestry aspects followed by soil and water conservation management and agronomy of forage crops under main areas.

In sub areas, majority of small and large farmers need training on improvement and management of degraded rangelands followed by hortisilvipasture and either year round fodder production or package of practices of important forage crops, while medium farmers need training on hortisilvipasture followed by improvement and management of degraded rangelands and package of practices for important forage crops.

Small farmers were reluctant in participating in the training because of poor monetary conditions, small holding, inadequate irrigation facilities, illiteracy and dominance of degraded rangelands. On the other hand, medium farmers feel difficulty in participating in training because of inadequate irrigation facilities, poor monetary status, illiteracy, dominance of degraded rangelands and unawareness; while large farmers were reluctant to participate because of marginal lands, inadequate irrigation facilities and unawareness.

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

As extension of the 'Mega project, three categories of farmers (large, medium and small) replicated at two sites, one at Sakrar and the other at Awas were selected from *kharif* 1993. Cropping pattern was prepared according to their requirement and suitability of the area. Improved technologies were introduced and fallow lands were put under forage production. Wasteland was utilized for silvipasture and hortipasture systems.

It was found that crop yields increased and more forage was available for their cattle as compared to base year. Milk production also increased considerably.

**Transfer of technology**

For popularization of fodder production technology developed by the Institute for the benefit of farmers, extension workers, dairymen and other users, various extension approaches were followed.

1. **Training programmes**

   Following training programmes were organised:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Title of training and sponsoring agency</th>
<th>Period</th>
<th>No. of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Grassland resources and their management-IFS probationers</td>
<td>13-14 Sept, 93</td>
<td>30</td>
</tr>
<tr>
<td>2.</td>
<td>-Do-</td>
<td>1-2 Oct, 93</td>
<td>30</td>
</tr>
<tr>
<td>3.</td>
<td>Forage and fodder production sponsored by Directorate of Extension MOA, Govt of India</td>
<td>8-15 Oct, 93</td>
<td>35</td>
</tr>
<tr>
<td>5.</td>
<td>Forage Production-Military officers from RVC Centre &amp; School, Meerut</td>
<td>14 -15 Feb, 1994</td>
<td>10</td>
</tr>
</tbody>
</table>

2. **Demonstrations**

   During *kharif* 1993, 19 field demonstrations on jowar + cowpea, two on guar and two on Dolichos were laid out at farmers field. During winter, 72 field demonstrations were conducted on improved fodder production technology relating to berseem and oats at farmers field in the villages around Jhansi, Datia, Shivpuri, Tikamgarh and Maú Nath Bhanjan districts. Besides, 5 front line demonstrations on mustard and lentil crops were also conducted.
Demonstrations on silvipasture, agroforestry, hortipasture systems on farmers field as well as at the FD Block were conducted. The total number of demonstration systems was 25.

Thus, total demonstrations laid out were 125.

3. Hill revegetation

The programme was undertaken by State Soil Conservation Deptt. in technical collaboration with IGFRI, Jhansi. The scientists of IGFRI gave technical know-how and some seed material.

Gahra-Pachwara hill development: Gahra hill (83.75 ha) and Pachwara hill (158.0 ha) were revegetated with *Cenchrus ciliaris*, *Chrysopogon fulvus*, *Sehima nurvosum* and *Stylosanthes hamata* by Soil Conservation deptt. under our technical guidance. Besides, saplings of plants i.e. *Acacia tortilis*, kher, neem., *Dalbergia sissoo*, subabool, silar, kardhai which were planted earlier were taken care of. The fodder grasses and legumes were utilized by local farmers though cut and carry system.

Tejpura hill development: On Tejpura hill (30.19 ha) *Cenchrus ciliaris*, *Chrysopogon fulvus*, *Sehima nurvosum* along with *Stylosanthes hamata* were planted by Soil Conservation deptt. under our technical guidance. Besides, trees like babool, subabool, silar, kher, neem, kardhai, shisham and bamboo which were planted earlier were cared this year. The grasses and legumes were allowed to cut and carry by the farmers.

4. Check dam protection in Tejpura watershed

9 check dams, 14 earthen bundhies and half km long water harvesting bundhies were protected by planting para grass on the lower slopes and *Cenchrus ciliaris*, kans and khas on upper portion of slope. This was done in collaboration with Soil Conservation deptt. of U.P.

5. Protection by vegetative cover alongwith Kharaya Nala near Uldan

On both side of nala, Para grass was planted on the lower side and hybrid napier, *Cenchrus ciliaris* and *Dichanthium annulatum* on the upper side. Besides, silvipasture was also established along with 'Nala' in which trees (subabool & aonla).
grasses (*Cenchrus ciliaris, Dichanthium annulatum*) and legume (*Stylosanthes hamata*) were planted.

6. Establishment of grass nursery

The planting material of thirteen green species and technical know-how were provided to establish grass nursery at Uldan by Soil Conservation Department of U.P.

7. Raising grass seedlings

The breeder seed of improved grass species varieties and technical advise was given to Dy Director, Soil Conservation (Watershed) Deptt, of UP to distribute the seedlings to the farmers and other agencies engaged in soil conservation and dairy development work.

8. Demonstration on hybrid napier and guinea grass

Twenty field demonstrations on hybrid napier No. 6 and guinea grass were conducted at Patha, Rajpura, Uldan, Imilia, Magarwara, Pachwara, Gahra and Churat villages of Bangra block.

9. Distribution of forage seeds

200 kg seed of berseem (Wardan) was given to 35 farmers of Punavali, Raksa, Dhikoli, Uldan, Sijara and Rampura villages as minikits for laying out field demonstrations. 180 kg seed of jowar was given to 36 farmers of Uldan, Sijara, Amanpura, Imlia, Rajwar and Satpura villages for field demonstrations. In addition, 100 kg seed of *Stylosanthes hamata* was distributed to 25 farmers of Pachwara, Amarpura, Sijara, Gahra, Imlia and Uldan villages for demonstration. The cost of the seed was born by the Soil Conservation Deptt. of UP.

10. Farmers Mela/Day

One Kisan Mela and one Kisan Day were organised at IGFRI Farm in which each time more than 700 farmers participated. Ten selected spots at the Research Farm were shown and explained to them. After field visit, the stalls having latest technology erected by different organizations and then buzz session (question-answer) were arranged where farmers, extension workers and scientists interacted with each other.

Besides, one "Women in Agriculture Day" was organised on 4th Dec. 1993 at Karali village in which more than 600 ladies participated.
11. Kisan Gosthi

Two kisan gosthi were organised during the period. In each of these gosthi, more than 500 farmers and local press reporters participated. Farmers took keen interest in the question-answer session.

12. Participation in Kisan Gosthi

The participation was made in the following Kisan Gosthi:

1. Organised by Soil Conservation Deptt. at Chirgaoi 7.7.93
2. Organised by Village Panchyat at Bhojla 11.9.93
3. Organised by NRCAF 19.9.93
4. Organised by IFFCO at Bhojla 16.10.93
5. Organised by IFFCO at Baral 17.12.93
6. Organised by Utteranchal AH at Pashulok 21-23, Dec 93
7. Organised by Yuva Samajvadi party at Kot Behta 22.2.94
8. Organised by IFFCO at Mirchwara 21.2.94
9. Organised by IFFCO at Baratha 3.3.94

13. Exhibition stall

The stalls were erected and latest technology was demonstrated to the farmers, extension workers and other visitors on the following occasions:

1. NRCAF Kisan Diwas held on 19.9.93
2. Gwalior Pradarshani held from 28.12.93 to 5.2.94
3. Bundelkhand Vikas Pradarshani held from 12.2.94 to 23.3.94
5. NRCAF Kisan Gosthi held on 9.3.94

14. Visitors

Seventy four groups consisting 1015 farmers, extension workers, development people and students from different places were appraised the research activities at the farm as well as outreach programmes and exposed to the technology developed by the Institute.
15. Transfer of Technology through letters and pamphlets

Seven hundred forty two quarries of the farmers, extension workers, state officers and NGOs were replied by giving suitable advise, providing extension literature through correspondence.

16. Radio/TV talks

The Institute scientists disseminated the IGFRI proven technology through Radio and TV talks for mass communication.
COORDINATED RESEARCH

ALL INDIA COORDINATED RESEARCH PROJECT ON FORAGE CROPS

(Coordinating Unit, IGFRI, Jhansi)

1. Varietal Development in Forage Crops

Multilocalational testing was done on fodder crops like cowpea, guar, rice bean, teosinte, bajra, maize, napier-bajra hybrid and guinea grass during kharif season and berseem, lucerne, oats and winter maize during rabi season. In addition to this, three range species viz. blue panic, marvel grass and anlan grass on perennial basis. On the basis of multilocalational testing, several varieties of many forage crops have shown promise (Table 42).

One variety each on three crops viz. UPC-8705 of cowpea, RLS-88 of lucerne and CAZRI-30-5 of Sewean grass (lasiurus sindicus) have also been identified in the Annual Workshop of the AICRP on Forage Crops (Table 43).

Several varieties with improved performance were identified for its consideration for release by the sub-committee on Crop Standards, Notification and Release of Varieties of Central Seed Committee. Varieties recently released for its cultivation are indicated in Table 44.

2. Improved practices for increased forage production

For year round green forage availability, the best rotation is maize - berseem - maize + cowpea in Tarai region of Uttar Pradesh yielding 210.5 tonnes of green fodder and 48.4 tonnes/ha of dry forage annually.

Growing of subabool in cocount gardens of Kerala gives additionally 3 tonnes/ha of green fodder (12 tonnes/ha of green fodder).

Maize for green cobs and green fodder is most remunerative winter crop in Uurulikanchan (Pune) and gives 73.3 tonnes of green fodder per hectare. Highest monetary return of Rs. 45000/- annually is also available from such a system at Tipfur (Karnataka).

In alkali soil of Faizabad (U.P) Rice-berseem is the most remunerative system giving about Rs. 35000/- per hectare annually. Even 75% recommended fertiliser level is sufficient to maintain the productivity at same level to that of full recommended
level of fertilisation. In Hisar (Haryana), sorghum-wheat is the most productive crop rotation giving 97 tonnes of green forage (equivalent yield).

Non symbiotic nitrogen fixing organisms are found to be quite effective in increasing yields of oats specially under no nitrogen fertilised condition at Hisar by a margin of about 30 per cent over non-inoculated situation. At Palampur (subtemperate region of H.P), the increase in yield was by about 100 per cent over control due to Azotobacter application.

Application of VAM fungi increased the yield of oats at Palampur was spectacular, almost 200 per cent increase in yield over control under non-nitrogen fertilised situation. VAM fungi application to crops like maize, pearl millet, sorghum and guinea grass increased forage yield by 6-32 per cent over the untreated control in alluvial (sandy loam) soil of Ludhiana of Punjab.

A combined application of Rhizobium + VAM increased stylo forage yield by 23% over untreated control at Vellayani (humid areas of Kerala). Individual application of Rhizobium or VAM had only marginal advantage (8-10%).

Application of 5 t pyrite/ha reduced the pH of alkali soil from 10.5 to 9.5. In such a habitat, para grass was the only plant to survive and produce even without pyrite application.

Table 42. Promising varieties of forage crops in advanced trial (multi-locational testing)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Varieties</th>
<th>Suitable area/ Habitat for use</th>
<th>Green fodder Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Kharif crops</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cowpea</td>
<td>UPC-9103</td>
<td>North-west</td>
<td>25.0 - 36.0</td>
</tr>
<tr>
<td></td>
<td>UPC-9103</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UPC-9202 &amp; IFC-901</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UPC-9103</td>
<td>South zone</td>
<td>16.5 - 30.0</td>
</tr>
<tr>
<td>Maize</td>
<td>FML-8</td>
<td>All India</td>
<td>16.0 - 35.0</td>
</tr>
<tr>
<td></td>
<td>APFM-8</td>
<td>North - east</td>
<td>14.0 - 36.0</td>
</tr>
<tr>
<td></td>
<td>FML-13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guinea grass</td>
<td>PGG-205</td>
<td>North-west</td>
<td>33.6 - 37.0</td>
</tr>
<tr>
<td></td>
<td>PGG-489</td>
<td>Central zone</td>
<td>84.3 - 104.5</td>
</tr>
<tr>
<td>Napier-bajra hybrid</td>
<td>APBN-1</td>
<td>South zone</td>
<td>60.6 - 71.1</td>
</tr>
<tr>
<td></td>
<td>BN-9201</td>
<td>Gujarat</td>
<td>78.0 - 80.8</td>
</tr>
<tr>
<td>Marvel grass</td>
<td>IGFRI-1981</td>
<td>All India</td>
<td>9.3 - 73.4</td>
</tr>
<tr>
<td>Anjan grass</td>
<td>IGFRI-99-1</td>
<td>Alkali soil</td>
<td>7.0 - 8.0</td>
</tr>
<tr>
<td>Blue panic</td>
<td>CAZRI-621</td>
<td>Semi - arid &amp; Arid areas</td>
<td>3.1 - 21.2</td>
</tr>
<tr>
<td></td>
<td>CAZRI-28</td>
<td>Alkali soil</td>
<td>8.0 - 8.7</td>
</tr>
<tr>
<td></td>
<td>CAZRI-347</td>
<td>Desert</td>
<td>3.0 - 3.8</td>
</tr>
</tbody>
</table>
### Bajra
- **Giant bajra**
  - RFB-2 & APFB-2
  - All India
  - 26.4 - 54.0
- **Summer bajra**
  - Giant bajra
  - APFB-1 & RFB-1
  - All India
  - 62.1 - 116.0
- **Teosinte**
  - TL-40
  - All India
  - 20.7 - 40.3

### Rabi crops
- **Berseem**
  - JHB-90-3
  - Central zone
  - 38.6 - 86.8
  - BL-87
  - North-west
  - 48.4 - 87.1
- **Oats**
  - JHO-886 & JHO-881
  - North-east
  - 23.8 - 46.3
  - JHO-882 & JHO-886
  - Central zone
  - 40.6 - 88.4
- **Lucerne**
  - RLS-88
  - South and central zones
  - 100.7 - 163.6

### Table 43: Variety identified for the consideration for release on the basis of superior performance on all India/zonal trials

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Area of adoption, yield level and special characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cowpea</strong> (Vigna ungericulata)</td>
<td>UPC-8705</td>
<td>Identified for release for its superior performance for All India use. Yields 30-45 t/ha of green forage and resistant to yellow mosaic virus and moderately resistant to root rot and collar rot diseases.</td>
</tr>
<tr>
<td><strong>Lucerne</strong> (Medicago sativa)</td>
<td>RLS-88</td>
<td>Identified for release for its consistently superior performance over the years as perennial variety for All India cultivation. The variety is resistant to major diseases and pests and yields 90-130 t/ha green forage annually. This is also a good seed producer yielding 300-400 kg/ha.</td>
</tr>
<tr>
<td><strong>Sewan grass</strong> (Lasialurus sindicus)</td>
<td>CAZRI-30-5</td>
<td>This variety has been identified for arid desert for its superior performance over the locations and over the years (4-5). It yields 10-20 t/ha green forage under desertic environment, good soil binder and nutritionally good.</td>
</tr>
</tbody>
</table>
### Table 44. Release of varieties of forage crops with area of adoption, yield level and special characteristics

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Area of adoption, yield level and special characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fodder Bajra</td>
<td>Raj. bajra chari-2 (UJJ-IV-M)</td>
<td>Entire bajra growing area, tolerant to major diseases and pest. Green forage yield ranges between 300-450 q/ha, and dry forage 70-90 q/ha, drought tolerant.</td>
</tr>
<tr>
<td></td>
<td>Fodder Cumbu-8 (TNSC-1)</td>
<td>Entire bajra growing area, moderately tolerant to major diseases and pests. Green forage yield ranges between 270-400 q/ha, and dry forage 55-90 q/ha, drought tolerant.</td>
</tr>
<tr>
<td>Fodder Sorghum</td>
<td>MESH-3</td>
<td>Suitable for entire country, multi cut. Green forage yield ranges from 500-850 q/ha with dry forage yield of 120-205 q/ha, moderate field tolerance to major diseases and pests.</td>
</tr>
<tr>
<td>Fodder Cowpea</td>
<td>Bundel Lobia-2 (IFC-8503)</td>
<td>For north-western part of the country comprised the states of Punjab, Haryana and Rajasthan. The yield levels are 250-450 q/ha of green forage and 55-95 q/ha of dry forage, moderately tolerant to leaf hopper and flea beetle, moderately drought tolerant.</td>
</tr>
<tr>
<td></td>
<td>Bundel Guar-1 (IGFRI-212-1)</td>
<td>For the entire guar growing tract comprised of Punjab, Haryana, Rajasthan and central parts of India. The yield levels are 220-350 q/ha of green forage and 47-75 q/ha of dry forage, resistant to leaf and bacterial blight (Xanthomonas and Alternaria) diseases and tolerant to major insect and pest under field condition.</td>
</tr>
<tr>
<td>Lablab beans</td>
<td>Bundel semi-1</td>
<td>This is the first variety released in this crop for its use in the entire country, yield level ranges from 220-350 q/ha for green forage and 48-75 q/ha for dry forage, resistant to all major diseases under field condition.</td>
</tr>
<tr>
<td>Berseem</td>
<td>UPB-110</td>
<td>This is the first variety of berseem released especially for its use in southern regions that is for the states of Andhra Pradesh, Karnataka and Nilgiris of Tamil Nadu, yield ranges between 450-650 q/ha of green forage and 50-80 q/ha of dry forage, resistant to all major diseases and insect pests under field condition.</td>
</tr>
<tr>
<td>Fodder maize</td>
<td>J-1006</td>
<td>This is the first fodder maize variety released by the state of Punjab and notified for its use in the state. Yield ranges between 300-450 q/ha of green forage and 65-105 q/ha of dry forage, resistant to yellow mosaic and tolerant to maize borers under artificial conditions.</td>
</tr>
<tr>
<td>Fodder cowpea</td>
<td>C-88</td>
<td>This variety is released and notified for the state of Punjab, yield ranges between 270-350 q/ha of green forages and 58-76 q/ha of dry forages, highly resistant to yellow mosaic. Comparatively tolerant and less attacked by leaf minor and semilooper under field condition.</td>
</tr>
</tbody>
</table>
Studies on compaction, storage and transportation of crop residues and grasses (IGFRI - NDDB Collaborative Research Project)

(P.D. Gupta, P.S. Chattopadhyay, R. K. Goyal & V.C. Pachauri)

The shearing characteristics of Dichanthium annulatum and Hetropogan contortus grasses were studied at 10, 20 and 30% of moisture levels. The average shearing strengths of Dichanthium annulatum at 10, 20 and 30% moisture contents were 84.4, 91.02 and 147.24 kgf/cm respectively. The shearing strengths of Hetropogan contortus at the corresponding moisture levels were 81.0, 116.7 and 203.6 kgf/cm² respectively. The shearing pressure required to shear of the grass stem increased as moisture content of the crop increased. Hence more power will be required to overcome the shearing resistance of the grass. At 10% moisture level the shear strength for both the grass was nearly equal but the difference increases for Hetropogan contortus having higher shear strength than Dichanthium annulatum up to 30% m.c.

The EMC of wheat straw and grasses at 30°C temperature for 33, 44, 63 and 76% relative humidities and at 40°C temperatures for 32, 49, 62 and 75% relative humidities were determined to study the drying characteristics of hay. The EMC for particular relative humidity decreased as the temperature increases. It is true with grasses and straw both. At 30°C temperature EMC was 5.12 and 13.79 under 33 and 76% RH for grasses and corresponding values of EMC for straw were 4.49 and 12.55 respectively.

EMC value increases with increase in relative humidity of the surrounding atmosphere at constant temperature. Therefore, grass and straw would not be dried below 5.10 and 4.49% moisture content to store these at 30°C temperature.

Grass bales of different storage period were analysed for the development of aflatoxin. It could not be detected upto storage period of 12 months in a grass bale of 30% moisture, 5% molasses and 2% urea. It indicates that grass bales of 30% moisture can easily be stored for one year, further study is also in progress for two years storage period.

Bailing at 350-450 Kg/m³ density, through IGFRI Densifying machine, does not affect the storage quality of product. Bales can be stored even without
polythene cover as aflatoxin could not be found in the bales stored without polythene.

Crude protein of stored grass bales were estimated for different treatments under 3, 6 and 12 months storage period. Bales without urea and low moisture showing minimum crude protein per cent and bales with urea and high moisture showing maximum crude protein per cent irrespective of storage period.

On dry matter basis crude protein of bales, stored without polythene cover. This may be due to more dry matter content of bales without polythene than bales with polythene cover.

Dry grass was treated with 5% molasses and 2% urea keeping 30% moisture level of the dry grass and densified at 400 kg/m$^3$ density. Feeding trial on growing crossbreed calves (Hostein X Haryana) was conducted after 30 days of densification. Twelve crossbred calves of about 2 years age were randomly divided into two groups. Group I (average live weight 210.00kg) was offered ad lib dry grass reserved at the time of densification (control) and concentrate mixture with approximately 20% crude protein was provided as per growth and maintenance requirement of individual calves. Group II (average live weight 203.00kg) was offered densified grass ad lib and concentrate mixture as given in group I. Feeding period extended to 85 days during which live weight record of the calves was maintained at fortnightly interval. At the end digestibility trial was conducted for a period of 7 days. The intake of dry grass and concentrate was recorded. Representative samples of dry grass, densified grass, concentrate was preserved for chemical analysis. After chemical analysis, the intake of dry matter and nutrients were calculated and digestibility coefficients obtained the intake of dry matter (kg/head/day), digestible crude protein (g/head) and total digestible nutrients (kg/head) in group I and II were 2.34 and 2.51; 616 and 649; 420 and 423 and 2.89 and 2.87 respectively in both groups and did not very significantly. Content of dry matter, organic dry matter, crude protein, crude fiber, ether fiber, acid detergent fiber in group I and II were also similar except crude fibre which was lower in experimental group (51.28 Vs 40.39). The body weight records suggest that the growth rate kg/head/day in group I and II was 297 Vs 271. The lower growth rate in both groups is attributed to heat stress during the months of May and June. Therefore, densification did not effect palatability and there is scope of curtailing concentrate allowance when 2% urea and 5% molasses densified grass is fed to growing calves.

The bales of wheat bhusa for 20 and 30% moisture with 0 and 2% urea by adding 10% molasses were prepared (baling bales at 10% moisture with and without molasses was not feasible).
To study the Utilization of *Sesbania sesban* grown under Agro-forestry System as animal feed.

1. Production potential of forage sorghum-gram sequence under different alley width of *Sesbania sesban* and irrigation treatments

(A. Rekib and N. P. Shukla)

Gram: Gram was sown on 22-10-92 on the *Sesbania sesban* alleys (no alley and at 4, 6 and 8m apart) with three irrigation treatments (no irrigation l, irrigation at branching l2 and 2 irrigations at branching and pod formation stages, l3).

Significantly highest grain (2.02 t/ha) and straw (3.15 t/ha) yields were obtained in plots with out alleys as compared to 4m apart alleys (1.61 t/ha grain and 2.33 t/ha of straw). Increasing alley width from 4 to 8m proportionately increased the grain and straw production. Differential alleys caused significant variation in plant height (51.6 cm) and grain yield/plant (20 g) at 4m alley in comparison to 8 alley 45 cm height and 15.3 g grain yield.

Grain, straw and crude protein yields of gram significantly increased from l1 (0.90 t/ha, 1.37 t/ha and 274.5 kg/ha) to l2 (2.08 t/ha, 3.07 t/ha and 367.8 kg/ha) and l3 (2.49 t/ha, 3.43 t/ha and 465.1 kg/ha). The number of grain / plant also increased significantly from 46.9 in l1, 75.3 in l2 to 91.5 in l3.

The number of pods and grain weight/plant also followed the similar trend. The plant population per running metre was significantly high (15.50 with l3) over l2 (12.3) and l1 (12.5). The plant heights were 44.2, 49.7 and 52.1 cm in l1, l2 and l3.

Sorghum: Sorghum (PC-6) was sown on 3.7.93 in *S. sesban* alleys (0, 4, 6 and 8 m apart) having three moisture regimes (rainfed (l1), irrigation at canopy temperature (Tc) - atmospheric temperature (Ta) value of 0°C, (l2) and 2°C, (l3) measured with infrared thermometer).

Sesbania alleys significantly influenced the green forage, dry matter and crude protein yield. Highest green forage (39.5 t/ha), dry matter (7.66 t/ha) and crude protein (0.55 t/ha) yields were recorded at alley treatments. Increasing the alley distance from 4 to 6 m and 6 to 8 m, significantly increased green forage yield. Dry matter yield of sorghum at 0.6 and 8 m alleys were at par and were significantly superior to 4 m alleys. Crude protein yield with 0 and 8 m alleys were at par but significantly superior to 4 and 6 m alleys. There were no effect of sesbania alleys on sorghum plant height and population/ unit area.

Moisture regimes significantly influenced green and dry matter yield of sorghum. Increasing levels of moisture regime from rainfed (32.6 t/ha) to 0°C Tc-Ta to - 2°C Tc- Ta (36.9 t/ha) increased the green forage yield significantly. However, increase in dry matter yield was only significant between l1 (6.62 t/ha) to l2 (7.41 t/ha).
Sesbania: Sesbania was harvested in May, July and Oct'93 and in January 1994. The green forage yield of Sesbania between May'93 to Jan'94 at 4, 6 and 8 m alley width were 63.2, 50.5 and 37.6 t/ha having 195, 156 and 160 t/ha. Dry forage and CP content of Sesbania were 16.86, 19.44, 20.11 and 21.51% in May, July, October and January respectively. Average CP yield was 3.80, 3.04 and 3.12 t/ha at 4, 6 and 8 m respectively.

**Total forage yield:** Total annual green forage 39.5, 91.7 85.2 and 74.4 t/ha; dry forage 7.66, 25.26, 22.92 and 23.36 t/ha were and CP yield 5.52 4203, 3530 and 3627 kg/ha was obtained at 0, 4, 6 and 8 m alleys from sorghum and Sesbania form May, 93- Jan'94. This shows that at 4 m alley highest amount of nutritious forage could be obtained.

2. Effect of planting width and lopping on the productivity of *Sesbania sesban* - *Brachiaria mutica* grown under waterlogged condition

(A. Rekib and N. P. Shukla)

This was first year of the experimentation. Sesbania were planted in alleys of 4, 6 and 8 m in May, 93 through transplating of seedlings and direct sowing on bothe sides of the ridges(30 cm X 30 cm). These were utilized for green fodder, green manure and fuel. Along with one absolute control, there were 10 total treatment combinations evaluated in RBD. Two cuts from *Brachiaria mutica* and 2 cuts from sesbania for green forage and green manure were obtained.

Highest yield of *B. mutica* (33.48 t/ha) was obtained in case of no alley. Among alleys treatments the highest yield of 32.12 t/ha was obtained when sesbania alleys were maintained at 8 m apart which was significantly superior over 4 m alleys (27.6 t/ha). The total yield of forage was highest with no alley (33.5 t/ha). Among alleys significantly higher yield was obtained at 8 m apart alleys (32.78 t/ha) which was significantly superior to 4 m apart alleys (28.78 t/ha). Yield from sesbania and para grass was comparatively low because this was the establishment year.

3. Nutritional evaluation of sesbania and para grass with growing heifer

(A. Rekib, N. P. Shukla and S. B. Maity)

In this study T1, T2 and T3 groups had 6 growing heifers in each, was offered 0, 28 and 40 % CP from sesbania; 70, 50 and 30% CP from concentrate and *ad lib* para grass. A feeding trial was conducted for 113 days. During 1st 48 days, the animals were offered sesbania silage while in the next 65 days, green sesbania was fed. Chemical analysis of feed and faeces, body weight gain of animals; nutrient intake from each feed component, and digestibility conefficient of nutrients was worked out.
The details of DM, CP intake per kg body weight gain (g/day) during silage and green sesbania feeding has been presented in table.45

This study indicated that (a) sesbania green forage was better than silage; (b) para grass was more palatable than sesbania, (c) 73.7% CP supply of growing heifer could be met by green sesbania and para grass; (d) DM and CP intake per kg body weight gain could be appreciably reduced by sesbania-para grass combination.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total DM intake:</td>
<td>(kg/100kg B.wt.)</td>
<td>2.72</td>
<td>2.77</td>
</tr>
<tr>
<td>TDN intake</td>
<td>(kg/100kg B.wt.)</td>
<td>1.694</td>
<td>1.763</td>
</tr>
<tr>
<td>DCP intake</td>
<td>(g/100 kg B.wt.)</td>
<td>229.1</td>
<td>277.0</td>
</tr>
<tr>
<td>DM intake</td>
<td>(kg per kg B. wt. gain)</td>
<td>9.70</td>
<td>7.98</td>
</tr>
<tr>
<td>CP intake</td>
<td>(kg Per kg B. wt. gain)</td>
<td>1.275</td>
<td>1.101</td>
</tr>
<tr>
<td>Body weight gain (g/day)</td>
<td>(i) Silage feeding</td>
<td>469.00</td>
<td>256.00</td>
</tr>
<tr>
<td></td>
<td>(ii) Green forage feeding</td>
<td>346.00</td>
<td>403.00</td>
</tr>
<tr>
<td></td>
<td>(iii) Overall</td>
<td>398.00</td>
<td>341.00</td>
</tr>
</tbody>
</table>

4. Feeding value of Sesbania forage on growing heifer when fed with Sorghum silage

(A. Rekib, N.P. Shukla and S. B. Maity)

This study was conducted by replacing para grass with sorghum silage. T1, T2 and T3 groups having 6 animals in each were offered 85.0, 52.0 and 31.0% CP from concentrate and rest from sesbania and sorghum silage. A digestion trial was conducted after 40 days of per-experimental period with 6 days collection period. DM matter intake in T1, T2 and T3 group from sesbania was 0, 19.6 and 33.3; from sorghum silage, it was 47.4, 52.1 and 44.9 and that of concentrate was 52.6, 28.3 and
21.8%. DM intake per 100 kg b. wt. was 3.25, 2.94 and 3.25 in T1, T2 and T3 respectively. CP intake from sesbania was 0, 29.5 and 51.2%. Digestibility co-efficient of CP, EE, CF and ash was high in T3 while in T1 DM and NFE Dig. was high but the kg b.wt. gain in T1, T2 and T3 groups were 6420.6, and 6685.5, 6261.4 g and 980.6 and 985.0 and 855.3 g respectively.

INTEGRATED DEVELOPMENT OF WASTELAND IN BUNDELKHAND REGION


The project has been taken up in Ambabai village of Jhansi (U.P) and Chopra village Datia (M.P)

Soil and Water Conservation Engineering

Detailed contour surveying of about 400 ha undulating area at Chopra site was completed. Detailed planning, designing, and estimations for various soil and water conservation works/ measures were done accordingly. These SWC measures includes mainly contour furrowing, staggered pitting cum discing, contour stone dykes, loose boulder checkdams, micro water pools (Ponds) small, contour trenching, contour ploughing and some of the masonry structures like run off plots, brick masonry etc.

M.S. Divisors were installed in seven plots of 3% slope and one of 4% slope. The divider box and whole assembly were installed on a masonery base. A common drainage channel was provided at D/ S of each plot to facilitate the drainout of daily ranoff from plots. The calibration was also done.

On an average the runoff in the plots with 3% slope was varying between 47.7% to 66.5% of rainfall, depending upon the characteristics of different storms. Maximum runoff (66.5%) was observed on 10th Sept. 93 when there was a severe rains of 157.5 mm in a single day. Total soil loss during the year was varying between 11.3 t/ha to 12t/ha in the different plots. Maximum one day soil loss of 0.9 t/ha was observed on 10th Sept. 93.

The runoff, soil loss values in the plot with 4% slope were 8-10% and 7-8% as compared to plots with 3% slope.

Infiltration studies were conducted at 72 locations at chopra site using double ring infiltrometers at three specified locations viz-a 10 ha. microwatershed (treated with contour furrowing and pitting-cum discing, with considerable soil depth) ; Foot/ cart tracts in the forest lands ; and a 5 ha catchment having poor soil depth and treated with contour furrows. The constant infiltration rates in above cited locations were varying 2. 6-8.3 ; 0.5-2.6 and 3.6-9.4 cm/hr respectively. While the cumulative
water intake in initial 180 minutes were 9.4-36-0; 2.35-8.45 and 15.1-38.9 cm. respectively. The suspended silt concentration were in the range of 1.1 to 7.2 g/liters.

Runoff pattern was observed in a slopy catchment treated with loose boulders checkdems. The base flow was observed till 29 days after withdraw of mansoon (i.e. last rain). Attempts were made to quantify the baseflow rates using conventional technique i.e., measuring the flow at D/s in a container and noting the time required to fill it at close time intervals. The base flow rates thus observed were low, varying between 100 liter/hr - 20 liter/hours. Earlier, (prior to treatment of catchment) the baseflow were almost nil.

The daily storage losses from a large size and four micro ponds were estimated by observing the change in daily/weekly water level with respect to a fixed bench mark. The losses were in the range of 0-10MM per day width a maximum 12 mm/day in the months of March, 94. In micro Ponds the stored runoff disappeared completely after 29 days of last rainfall.

Revegetation

At Ambabai site of the project 11,000 seedlings of 22 different tree species were planted in an area of 80 ha both at farmers field/ wastelands and goverment wastelands while at Chopra site 18,450 seedlings of 20 different tree species were planted in an area of 150 hectare.

Major species planted were Albizia amara, A. lebbek, Azadirachta indica, Bambusa species and Emblica officinalis. In addition, about 600 naturally occurring bushes of Zizyphus nummularia were budded with Umran and Banarasi Kadaka varieties of Z. mauritiana covering an area of 160 ha both at farmer’s field and other wasteland areas at Ambabai. Nearly 2.5 ton seed of different grasses viz. Cenchrus ciliaris, Setigerus, Dichanthium annulatum, Chrysopogon fulvus, Sehima nervosum and Pannisetum pedicellatum has been sown/ transplanted through seed/ seed pellets/ seedlings covering an area of 600 hectare. About 3.5 ton seed of Stylosanthes hamata has been sown covering an area of about 600 hectare.

Silvipastoral system

Albizia amara, Azadirachta indica and Delbargia sissoo basd silvipastoral systems were established. Both A. amara and D. sissoo showed about 84% survival while A. indica showed lower (60%) survival rate. Growth in terms of plant height and collar diameter was maximum in case of A. amara followed by D. sissoo and A. indica. Pasture production under these three tree species ranged from 3.44 to 4.47 t/ha (dry weight). A. amara based system showed marginally higher pasture production than A. indica and D. sissoo based systems.

Hortipastoral system

(i) Aonla (Emblica officinalis) based system
Aonla based hortipastoral system was established and its various components were monitored. Aonla trees showed overall survival of 87% under rainfed condition after three years. Plant height and collar diameter showed steady growth over years. Production of pasture component increased in the second year (Table 46(a), (b)).

Table 46 (a) Performance of Aonla (Emblica officinalis) based hortipastoral system over the years.

<table>
<thead>
<tr>
<th>Tree Component</th>
<th>Plant height (cm)</th>
<th>Plant growth Collar Diameter (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>39.5 142 199</td>
<td>0.45 1.71 3.73</td>
</tr>
</tbody>
</table>

Table 46 (b) Pasture production (Dry wt t/ha)

<table>
<thead>
<tr>
<th>Pasture Component</th>
<th>Camphor grass</th>
<th>Stylosanthes hamata</th>
<th>C. ciliaris + S. hamata</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.19 6.26 5.56</td>
<td>1.78 5.76 7.10</td>
<td>3.63 7.96 4.72</td>
</tr>
</tbody>
</table>

(ii) Ber (Zizyphus sp.) budding

Z. mauritiana cv. Umran and Banarasi Kadaka showed tremendous increase in terms of fruit yield, its quality, forage and fuelwood yield over naturally occurring Z. nummularia (control) when budded on other naturally occurring Z. nummularia (Table-47).

Energy plantation

Among the tree species trail for energy plantation Acacia tortilis exhibited maximum growth as compared with Prosopis juliflora and Inga dulcis in the initial years (Table-48).

Live fencing

Bambusa sp., Parkinsonia and Prosopis juliflora, were tried as live fencing. Although survival percentage was low, Bambusa sp. showed maximum growth followed by P. adulatum and P. juliflora (Table-49).
Table- 47 Comparison between production of naturally occurring Z.nummularia cv. Umran and Banarsi Kadaka.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Plant height (cm)</td>
<td>184.4</td>
<td>236.00</td>
<td>299.5</td>
<td>308.0</td>
</tr>
<tr>
<td>2.</td>
<td>Collar diameter (cm)</td>
<td>1.7</td>
<td>2.32</td>
<td>4.6</td>
<td>5.05</td>
</tr>
<tr>
<td>3.</td>
<td>Fruit production (Kg/tree)</td>
<td>0.17</td>
<td>--</td>
<td>5.1</td>
<td>20.5</td>
</tr>
<tr>
<td>4.</td>
<td>Av. fruit weight (g)</td>
<td>1.2</td>
<td>--</td>
<td>10.6</td>
<td>40.0</td>
</tr>
<tr>
<td>5.</td>
<td>Av. fruit size length</td>
<td>1.5</td>
<td>--</td>
<td>3.6</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>(cm) <strong>width</strong></td>
<td>0.9</td>
<td>--</td>
<td>2.5</td>
<td>4.0</td>
</tr>
<tr>
<td>6.</td>
<td>T.S.S. (Brisk)</td>
<td>22.00</td>
<td>67.42</td>
<td>72.0</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Acidity (Meq: NaOH/100 g dry matter)</td>
<td>107.6</td>
<td>8.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Fuelwood production dry wt. per tree</td>
<td>0.40</td>
<td>0.80</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Leaf fodder production dry wt. Kg/tree</td>
<td>0.40</td>
<td>--</td>
<td>0.45</td>
<td></td>
</tr>
</tbody>
</table>

Table-48 Comparative growth performance of tree species for energy plantation

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Tree species</th>
<th>Plant height</th>
<th>Growth (cm) Collar diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Acacia tortilla</td>
<td>235</td>
<td>3.06</td>
</tr>
<tr>
<td>2</td>
<td>Inga dulcis</td>
<td>87</td>
<td>1.07</td>
</tr>
<tr>
<td>3</td>
<td>Prosopis juliflora</td>
<td>205</td>
<td>1.44</td>
</tr>
</tbody>
</table>

Table-49 Comparative growth performance of tree species as live fence

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Tree species</th>
<th>Growth (cm) Collar diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Bambusa sp.</td>
<td>136</td>
</tr>
<tr>
<td>2.</td>
<td>Parkinseonia accleta</td>
<td>109</td>
</tr>
<tr>
<td>3.</td>
<td>Prosopis juliflora</td>
<td>103</td>
</tr>
</tbody>
</table>

Livestock management

A high pedigreed buffalo bull of Murrah breed has been provided to a farmer of Ambabai village for breeding of local buffaloes. 90 buffaloes have been served by
this bull during 1992 and 1993. 25 calves were borne from these buffaloes where the ratio of male and female calves was 1:1.

Health control of animals: 189 cases of sick animals of Ambabai/Hastinapur village have been treated against different diseases. Castration of 29 male scrub bulls have been done. Deworming of 84 animals along with control of ectoparasites has been done.

Silage making Sorghum (M.P. char) stover's silage was prepared in a pucca pit (8'×6'×4') at a farmer's field of Ambabai village. M.P. char stover, (10q) was harvested during second week of October, 1993, chaffed with a hand, chaff cutting machine and ensiled in a pucca pit. The silage was opened during third week of February, 1994 and fed to the adult animals (2 buffaloes, 2 bullocks and 1 cow). The silage was of excellent quality having pleasant smell, and brown colour. On an average the dry matter intake was 2.10 kg/100 kg body weight. The original material (M.P. char stover) contained 39.5% dry matter and 5.5% crude protein whereas the silage contained 40.5% dry matter and 5.5% crude protein. The dry matter loss in silage making was 6.25% only. The pH of silage was 4.8 and silage had low levels of lactic acid and volatile fatty acids.

Socio-economic Survey

(i) Land use pattern: The details of land utilization for the year 1993-94 indicate that about 56% of the total area of the village is under cultivation. The second largest area (21%) is covered by wastelands and pasture lands followed by area under other uses (6.24%), Barren and uncultivable lands (5.56%) and fallow lands (2.08%).

Magnitude of change: The study of magnitude of change in the land use pattern (1993-94) over the base year 1991-92 indicates that the area under wastelands and fallow lands has reduced from 28.65% to 20.95% and 3.76% to 2.08% respectively. These area might have become under cultivated or miscellaneous tree crops area. Because cultivated area and land under miscellaneous tree crops have increased from 57.83% to 64.89% and 0.05% to 0.27% respectively.

Change in the area of different crops: During khairil 1993 the area under crops was 467.1 ha which was 25.4% higher than the base year (1990). The highest area (191.6ha) was under groundnut, til (80.1ha), urd (54.3ha) and maize (47.6ha). It was observed that area increased under groundnut, urd, moong and maize by 59.8, 93.4, 21.3 and 22.2 percent, respectively over the base year (1990). Whereas, area under til was decreased by 10.3%.
During rabi 1993-94, total area under crops was 623.4 ha which was 3.4\% higher than the base year (1990-91). The major crop was wheat covering 426.1 ha. It was followed by gram (123.8 ha), mustard (38.3 ha), barley (20.4 ha), ber (7.1 ha), lentil (7.8 ha) and berseem (6.5 ha). It is interesting that area under mustard, pea, lentil, berseem and wheat was increased percent over the base year. However, it was decreased in gram and barley by 20.8 and 10.2 percent, respectively.

Changes in the production of different crops: During kharif 1993 the production under urd, groundnut and maize was increased by 82, 71 and 47 per cent, respectively on base year and declined under til and moong by 46.5 and 24 per cent respectively.

During rabi season of 1993-94 the total production under mustard, pea, lentil, berseem, wheat, gram and barley was increased by 5507, 914, 674, 287, 56, 14 and 3.5 percent respectively.

The fertilizer consumption in crops, in general, has been increased while seed rate of berseem, wheat, barley and lentil reduced by 37, 1.3, 24 and 3 per cent respectively.

It was observed that $N_2O_5$ consumption in wheat increased from 74.4 kg/ha and 49.6 to 58.0 kg/ha, respectively. Whereas, barley, pea, gram, lentil, mustard and berseem which were not being fertilized earlier now have been fertilized with $N$ with $P_2O_5$. On the whole barley, pea, gram, lentil, mustard and berseem are being fertilized with 13.8, 8.7, 2, 6, 5.0, 31.0 and 52 kg $N$ and 5.3, 22.3, 6.6, 12.6, 12.0 and 16.5 Kg $P_2O_5$/ha, respectively.
WESTERN REGIONAL RESEARCH STATION
AVIKANAGAR

The Western Regional Research Station (IGFRI) was started in 1987 to cater the need for region based research on forage production. The station was established in 80 ha land of Central Sheep and Wool Research Institute, Avikanagar. This centre is of vital importance to semi-arid regions of Rajasthan, Gujarat and Haryana, having similar nature of climate, where huge area of land can be put under crop cultivation. The station has peculiar environment such as poor soil, sandy soil fertility and productivity care and erratic rains 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.

WRRS-2 : STUDY ON AGROSILVIPASTORAL SYSTEM
(Fateh Singh)

1. Effect of trees on the yield of range grasses and vice-versa

The four fodder trees were *Alianthus exelsa*, *Acacia nilotica*, *Prosopis cineraria* and *Albizia lebback* and three range grasses were *Cenchrus ciliaris*, *Cenchrus setigerus* and *Panicum antidotale*.

Every tree species were sown to see the effect of grass on the height and collar diameter of tree. There were sixteen treatment combinations.

*Cenchrus setigerus* produced maximum biomass production followed by *Cenchrus ciliaris*. The *Panicum antidotale* produced lowest biomass among all the grasses, tried in the experiment. Maximum height and collar diameter was recorded in *Albizia lebback*. It was observe that *Albizia lebback* was fast growing tree among all the tree, followed by *Alianthus exelsa*. Lowest height and collar diameter were recorded under *Prosopis cineraria*. The yield of grass was not affected by the trees and vice-versa. Maximum growth of the trees was recorded from June to December and minimum from March to June.

2. Effect of different spacing on the yield of *Cenchrus ciliaris* and *Panicum antidotale* under *Acacia nilotica*

This was the sixth year of the experiment. The grasses were *Cenchrus ciliaris* and *Panicum antidotale*. There were twelve treatment combinations.
The *Cenchrus ciliaris* produced higher tonnage over *Panicum antidotale* in all treatments, however wider spacing produced slightly higher yield over narrow spacing. There were twelve treatment combinations.

The *Cenchrus ciliaris* produced higher tonnage over *Panicum antidotale* in all the treatments, however wider spacing produced slightly higher yield over narrow spacing. There were no significant differences in the height and collar diameter. However, slightly higher growth was recorded under wider spacing over narrow spacing.

3. Horti - Pasture - system

Three varieties of Ber namely Gala, Save and Mundic were transplanted at a distance of 6 meter row to row and plant to plant (6x6 m). *Cenchrus setigerus* was transplanted at 50 cm apart rows in between Ber plants. The pruning and trimming of Ber was done. It was observed that there was no adverse affect of grass on the growth of Ber plants.
SOUTHERN REGIONAL RESEARCH STATION
DHARWAD, KARNATAKA

The centre established in 1987 is engaged in research on improvement, and management aspects of grasses, and cultivated fodder crops of peninsular India. The centre is also involved in seed production of range grasses and legumes and conduct coordinated trials on fodder crops.

Total rainfall of 799.3 mm was received during April to December 1993 at Dharwad. The rainfall distribution is as under:

<table>
<thead>
<tr>
<th>Month</th>
<th>Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>162</td>
</tr>
<tr>
<td>May</td>
<td>101.7</td>
</tr>
<tr>
<td>June</td>
<td>88.5</td>
</tr>
<tr>
<td>July</td>
<td>166.0</td>
</tr>
<tr>
<td>August</td>
<td>68.1</td>
</tr>
<tr>
<td>September</td>
<td>44.6</td>
</tr>
<tr>
<td>October</td>
<td>266.2</td>
</tr>
<tr>
<td>November</td>
<td>8.4</td>
</tr>
<tr>
<td>December</td>
<td>39.6</td>
</tr>
</tbody>
</table>

The climate is characterised by the absence of marked winters and a practically uniform temperature of about 27°C throughout the year. The mean annual temperature ranges from 20.3°C during December to 28.8°C during May.

SRS-1: COLLECTION, INTRODUCTION AND EVALUATION OF RANGELAND SPECIES.

1.6 Genealogy of Range grasses *Dichanthium annulatum*, *Caricosum* and *Sehima nervosum*.

(P.K. Jayan And D. H. Sukanya)

During the year, three grass *Dichanthium annulatum*, *Caricosum* and *Sehima nervosum* were taken up for investigation.

Natural grass cover of the region is represented by *Sehima nervosum* and *Dichanthium annulatum* and is dominated by *Sehima nervosum* which covers about 36 million ha. in the central and southern parts of India.

Based on the survey of the grasslands around Hubli-Dharwad and Belgaum certain variable forms (morphologically distinct) in grasses *Dichanthium annulatum*, *Caricosum* and *Sehima nervosum* have been identified during June-July 1993.
Three populations each in *Dichanthium annulatum*, *Caricosum* and *Sehima nervosum* were differentiated from the natural grasslands of this region.

**D. annulatum**

*Population* - I: Erect bunchy growth habit; early maturing; profuse tillering; long and thin internode; node light purple; leaves narrow; leaves and stem glaucous; average green forage yield - 140 g/plant.

*Population II*: Erect loose type; early maturing; tillering ability low; node light purple; internode light yellow; leaves dark green; green forage yield 120 g/plant.

*Population III*: Semi erect; late maturing; tillering ability greater; node purple; internode pale green; lower portion of leaf sheet purple; internode pale green; lower portion of leaf sheet purple; leaf dark green; green forage yield 28 g/plant.

**D. caricosum**

*Population* - I: Semi erect bunchy growth habit; late maturing; tall; greater tillering ability; node dull purple; stem and leaf dull green; average green fodder yield 454 g/plant.

*Population II*: Prostrate growth habit; late maturing; tall; lesser tillering ability; node dull purple; stem and leaf dull green; average green forage yield 242 g/plant.

*Population III*: Prostrate growth habit; late maturing; tall; medium tillering ability; node dark purple; lower portion of leaf sheet purple; stem and leaf dark green; average green forage yield 292 g/plant.

**Sehima nervosum**

*Population* - I: Erect bunchy type; late maturing; tall leafy; stem and leaf glaucous; tillering ability greater; average green forage yield 285 g/plant.

*Population II*: Procurement growth habit; early maturing tall; tillering ability greater; node; leaf sheet; leaf margins and spike pale to deep purple; average green forage yield - 330 g/plant; incidence of blight heavy.

*Population III*: Semi erect open growth habit; medium late maturing; tall; tillering ability low; internode and spike pale yellow; average green forage yield 217.5 g/plant.
1.7 Studies on productivity and persistency of grass/legume association

(P.K. Jayan and M. S. Raut)

The effect of different levels of nitrogen (0, 20, 40 and 60 kg. N/ha) and introduction of perennial legumes (*Stylosanthes hamata*, *Scabra*, *Macroptilium atropurpureum*, *Centrosema pubescens*) in grasses * Dichanthium annulatum*, *Heteropogon contorus* and *Sesima nervosum* were studied. The application of nitrogen fertilizers improved forage yield in grasses but the same was low when compared to the total yield obtained from legume and grass/legume mixtures had resulted in higher yields where as in grasses fertilized with nitrogen same was obtained under 60 kg. N/ha treatment. Forage yield from the grasses + Siratro was recorded to be highest.

SRS- 2 : STUDIES ON AGRONOMIC ASPECTS OF PERENNIAL CEREAL/LEGUMES INTERCROPPING SYSTEMS AND AGROSILVIPASTURAL SYSTEMS

(M.S. Raut and P.K. Jayan)

2.1 Agronomic studies on perennial cereal forages and legumes in different cropping systems under irrigated conditions.

2.1.1 Inter- cropping annual/perennial fodder crops with Napier-Bajar hybrid at different planting patterns.

Second year (NB) treatments consisted the combinations of three planting patterns of NB hybrid viz. 0.75 x 0.50 m; 1.50 x 0.50 m and 3.00 x 0.50 m and three intercrops viz. Lucerne throughout the year, Cowpea Berseem + Sarson and Cowpea - Oat alongwith sole hybrid at 0.75 x 0.50 m.

Total green forage production of hybrid decreased significantly (96.4 t/ha) due to intercropping as compared to sole hybrid (114.5 t/ha).

Planting of hybrid at 0.75 x 0.50 produced highest green forage (125.6 t/ha) followed by its planting at 1.50 x 0.50 m (96.5 t/ha) and 3.00 x 0.50 m (67.1 t/ha).

The total green forage production from intercropping (103.2 t/ha) was lower by 9.9 percent as compared to sole crop of hybrid (114.5 t/ha). The planting pattern of 0.75 x 0.50 resulted in significantly high total green forage yield (126.5 t/ha) followed by 1.50 x 0.50 m (102.8 t/ha) and 3.00 x 0.50 m (79.9 t/ha).
The intercropping of Cowpea-Oat in Bajra hybrid resulted in the highest total green forage (111.5 t/ha) followed by intercropping of Cowpea Berseem + Sarson (101.9 t/ha).

The contribution by intercrops to the total intercropping yield was maximum when intercropped in hybrid planted at 3.00 x 0.5 m (16.0 percent) and the lowest at 0.75 x 0.5 m (0.71 percent).

2.1.2. Studies on intercropping of oat/lucerne in guinea grass

(Panicum maximum) at different planting patterns

In second year of experiment treatment consisted the combinations of two planting patterns of guinea viz. guinea in skipped alternate rows (1.00 x 0.25 m) and paired rows (0.50 : 1.00 : 0.50 m), and two intercrop treatments viz. Lucerne throughout the year and Cowpea- Oat alongwith sole guinea at 0.50 x 0.25 m.

No difference was observed in the green forage yield of guinea due intercropping (78.5 t/ha) or sole cropping (78.2 t/ha). Paired row planting resulted in 6.4 per cent higher green forage yield of guinea as compared to its planting in skipped alternate rows (75.9 t/ha).

The total intercropping yield (83.7 t/ha) was 6.6 percent higher than sole guinea (78.2 t/ha). Intercropping of Cowpea - Oat in guinea planted in paired rows produced higher green forage (95.2 t/ha) as compared to skipped alternate row (83.4 t/ha).

SRS -3 : VARIETAL EVALUATION OF CULTIVATED FORAGE CROPS UNDER ON-STATION AND CO-ORDINATED TRIALS.

(D.H. Sukanya and P.K. Jayan)

Co-ordinate trials:

Cowpea

In an initial evaluation trial (IET) out of thirteen entries IFC- 9301 (230.56 q/ha) and DRC- 1 (233.33 q/ha) were at par with checks UPC- 5286 (233.33 q/ha) and UPC- 287 (227.78 q/ha), while in the advanced varietal trial (AVT) IFC -901 (240.28 q/ha) was found to be superior.

Fodder Bajra

Among the thirteen entries none was better than Giant Bajra in IET.
Multicut Oats

In three cuts the entries JHO-995, JHO-996 in IVT and JHO-891, JHO-893 and OL-529 in AVT were superior as multicut Oats.

Lucerne

The entries LLC-3, RL-89-2 and RLS-88 as perennials and Poona, Co-1 and V-3 as annuals were found promising out of six perennial and nine annual entries.

Station trials

Hybrid Napier

Among twelve napier hybrids evaluated for two years, PBN-16, IGFRI-7 and CN-8 were identified as good with green fodder yielding potential of 1500 q/ha in five cuts per year.

Guinea grass

PGG-123 was identified as the best. A local selection of guinea DRSGG-1 was equally good with 1200 q/ha of green fodder in seven cuts.

Off season Oats for advancing generation

Nine segregating lines of Oats were grown in Kharif. Good growth and seed stand was observed in all the lines.

SRS-4: GENETIC IMPROVEMENT OF FORAGE BAJAR AND Bajra x Napier Hybrids For Quality And Productivity.

(D.H. Sukanya and P.K. Jayan)

Germplasm collection and maintenance

One hundred and ninety seven fodder Bajra germplasm lines and eleven Napier germplasm have been maintained. Two hundred fodder Bajra and fifty six Napier germplasm were new additions collected from ICRISAT and TNAU respectively.

Germplasm evaluation

Significant variability was observed among sixty seven Napier lines evaluated for morphological character, days to flowering and duration of flowering, time of
anthesis. Eighteen Napier lines which had not flowered at Coimbatore, flowered in this region.

Fodder Bajra germplasm and selected fodder Bajra lines were assessed for various characters. Two hundred new fodder bajra germplasm lines, differed significantly for a number of traits and yield. Vigorous lines with good fodder yield have been selected.

Wide range of variability was observed in one hundred and ninety seven lines of fodder Bajra selected for this region. Most of the observed variability was attributed to genotypes.
PUBLICATIONS


2. Papers presented at the Seminars/Workshops/Symposia, etc.


Ashok Kumar and D.P. Handa. 1994. Sampling for yield estimation in Stylo (Stylosanthes sp.) communicated to RMSI, Jhansi for presentation in International Symposium to be held at New Delhi during 1994.


Eco-restoration of Aravalli Hills, held from 23-24 February, Haryana Forest Deptt., Gurgaon.


Singh, S.N., Khan, A.A., 1993. Storability of maize & sorghum seeds as influenced by botanical extracts under ambient condition. Abstract in journal of Mycology and Plant Pathology to be held at Udaipur in International Conference entitled "Global Conference on Advances in Plant Diseases and their Management".


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C.R. Rawat, Ph.D., Sr. Scientist (Agronomy)
Khubi Singh, M.Sc., Sr. Scientist (Statistics)
G.P. Shukla, Ph.D., Sr. Scientist (Plant Breeding)

Regional Station, Srinagar (J & K)

B.K. Misri, Ph.D., Sr. Scientist (Economic Botany) & I/C Station (Deployed to G.M. Division, Jhansi)

Regional Station, Avikanagar (Rajasthan)

Fateh Singh, M.Sc., Sr. Scientist (Agronomy) & I/C Station
Mallaya, Ph.D., Sr. Scientist (Economics)

Regional Station, Dharwar (Karnataka)

P.K. Jayan, Ph.d., Sr. Scientist (Economic Botany) & I/C Station
M.S. Raut, M.Sc., Sr. Scientist (Agronomy)
D.H. Sukanya, M.Sc., Scientist (Plant Breeding)
II. TECHNICAL

A.K. Srivastava, Sr. Technical Officer (T-7)
R.K. Verma, Veterinary Officer (T-7)
M.S. Sharma, Farm Manager (T-6)
Dodamani Amallappa, Instrumentation (T-6)
N.C. Srinivas, Technical Officer (T-6)
M.M. Rastogi, Technical Officer (T-5)
C.B. Mishra, Technical Officer (T-5)
Sunil Gupta, Seed Production Officer (T-5)
S.K. Rajpali, Technical Officer (T-5)
R.B. Mathur, Technical Officer (T-5)
D.K. Bhutani, Technical Officer (T-5)
Shree Ram Sikanya, Technical Officer (T-5)
C.P. Gupta, Technical Officer (T-5)
Mahi Pal Singh, Farm Superintendent (T-5)
H.N. Sharma, Technical Officer (T-5)
B.L. Barodia, Technical Officer (T-5)
Pramod Kumar Dwivedi (T-5)
Ram Singh (T-5)
Gyasi Lal, Seed Production Officer (T-4)
P.K. Karpe (T-4)
M.N. Naugraiy (T-4)
Surendra Kumar (T-4)
Kanhai Singh (T-4)
G.P. Nigam (T-4)
N. Vishwanathan (T-4)
O.N. Arya (T-4)
Anil Kumar Srivastava (T-4)
S.C. Richarya (T-4)
Indra Pal Singh (T-4)
Rajendra Singh parihar (T-4)
Nar Singh (T-4)
III. ADMINISTRATIVE

Atul Prakash Trivedi, Finance and Accounts Officer (w.e.f. 21.6.93)
P.N. Singh, Finance and Accounts Officer (up to 22.6.93)
Sanjay Kant, Senior Administrative Officer (w.e.f. 30.4.93)
H.C. Saxena, Administrative Officer
Gauri Shankar, Asstt. Administrative Officer
L.S. Sharma, Asstt. Administrative Officer
O.P. Dubey, P.A. to Director
Veer Singh, Superintendent
S.N. Dubey, Superintendent
G.D. Dubey, Superintendent
N. Arora, Superintendent (w.e.f. 24.12.93)
S.L. Hukmani, Superintendent (w.e.f. 1.10.93)
A.N. Nimje, Superintendent (w.e.f. 1.10.93)

IV. AUXILIARY

V.K. Litoria, Medical Officer
Statement showing headwise expenditure during 1993-94

<table>
<thead>
<tr>
<th>Head</th>
<th>Non plan</th>
<th>Plan</th>
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<tbody>
<tr>
<td>1. Pay and allowances</td>
<td>237.98</td>
<td>-</td>
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<tr>
<td>2. T.A.</td>
<td>4.00</td>
<td>0.82</td>
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<td>3. Recurring contingencies</td>
<td>63.50</td>
<td>44.58</td>
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<tr>
<td>4. Non-recurring contingencies</td>
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<td></td>
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<tr>
<td>(i) Works</td>
<td>-</td>
<td>60.98</td>
</tr>
<tr>
<td>(ii) Equipments</td>
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<td>30.86</td>
</tr>
<tr>
<td>(iii) Vehicles</td>
<td>-</td>
<td>3.86</td>
</tr>
<tr>
<td>(iv) Others</td>
<td>-</td>
<td>18.73</td>
</tr>
<tr>
<td>Total</td>
<td>305.48</td>
<td>159.83</td>
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</table>
Inaugural Session of NARP Training Course on Agroforestry, Forage Production and Animal Nutrition

Visit of Distinguished Visitors to Wasteland Development site in Ambabai Village
Workshop/Training on Integrated Wasteland Development and Drought Prone Area Programme

Inaugural Session of Short Term Course on Silvipastoral Systems Research
A view of Celebrations of Hindi Week

A view of Women in Agriculture Day organized at Ambabai Village
A view of Function organized to mark Institute Day

Kisan Mela and Gosthi organized at IGFRI Central Research Farm