IGFRI
ANNUAL REPORT
1988

INDIAN GRASSLAND & FODDER RESEARCH INSTITUTE
JHANSI-284003  INDIA
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CONTENTS

1. General .......................... 1
2. Division of Plant Improvement ..... 5
3. Division of Agronomy ................. 23
4. Division of Grassland Management .... 31
5. Division of Agro-silvipasture ........ 41
6. Division of Soil Science ............. 51
7. Division of Plant Animal Relationship . 59
8. Division of Seed Technology ......... 65
9. Division of Plant Physiology and Biochemistry 72
10. Division of Plant Protection .......... 81
11. Division of Agricultural Engineering and Post Harvest Technology 93
12. Division of Rural Economics and Biometrics 102
13. Division of Extension and Training ... 109
14. Inter-Institutional Collaborative Research 112
15. Coordinated Research ............. 116
16. Regional Station, Srinagar (J&K) .... 124
17. Regional Station, Avikanagar (Rajasthan) 128
18. Regional Station, Dharwad (Karnataka) 133
19. Third International Rangeland Congress 138
20. Publications ........................ 141
21. Distinguished Visitors .................. 157
22. List of Staff (Appendix-I) .......... 159
23. Budget (Appendix-II) ............... 165
The Indian Grassland and Fodder Research Institute, Jhansi established in 1962, has the mandate to carry out basic and applied research on all aspects of grasses, grasslands and fodder crops. During 1988, the Institute concentrated on advancing the research on evolving better varieties suited to different farming situations, agro-techniques for maximising forage production including seeds in various agro-climatic zones, improvement of natural grasslands/degraded lands through appropriate agrosilvipastoral system and developing post-harvest techniques for efficient utilization of forages.

The process of evaluation and monitoring of research projects has been systematized and the regrouping of ongoing research projects was done identifying the major mission oriented projects through interdisciplinary approach. The recommendations of the QRT are under implementation.

To make a dent in the system, the Institute had the privilege of organizing the Third International Rangeland Congress during the year. Important recommendations of the congress are also briefly included in this report.

The Inter-institutional linkages in the field of research and extension are also presented in the report.

Comments/suggestions on the report outlay will be welcomed and highly appreciated.

(PANJAB SINGH)
Director
GENERAL

INTRODUCTION

The Indian Grassland and Fodder Research Institute was established in November, 1962 at Jhansi for conducting, collating and coordinating research, training and extension on all aspects of grasses, grasslands and fodder crops at national level. Since than its activities are geared to develop technology on the subject for sustained production of forages to meet the needs of growing livestock population. The area under fodder crops has remained more or less static over last two and a half decades and is not likely to increase in near future due to preference for other crops. Therefore, the major emphasis has been laid to pursue research programme for increasing productivity per unit area per unit time of the cultivated fodder production system as well as augmenting forage production from wastelands, which otherwise are not being utilized.

OBJECTIVES

- To carry out basic and applied research on grasses, grasslands and fodder crops and to collate, coordinate and collaborate research in the country by centralising, direction, operation and superintendence.
- To evolve high yielding, fertilizer responsive, disease and pest resistant and superior quality forage crop varieties suited to different farming systems in various agroclimatic regions of the country by the use of modern techniques of plant breeding and through the application of research in other cognate disciplines.
- To develop agro-techniques for maximising forage production in irrigated, rainfed/dryland and other problem areas by evolving appropriate cultural-cum-fertilizer practices, intensive crop rotations, soil water management, system analysis and crop modelling, agroforestry, pasture and rangeland management.
- To carry out studies on soil survey and land use, physico-chemical characterization of forage growing areas, soil fertility and plant nutrition, biological nitrogen fixation and amelioration of problem soils for forage production.
- To undertake investigations on natural grasslands/ degraded rangelands for improving their productivity through ecological principles, species combination and establishment management techniques under different grass covers of the country.
- To develop and evaluate various crop/tree species combinations for silvipasture, hortipasture and agroforestry system for enhancing forage, fuel and timber production from marginal and submarginal wastelands under different agro-climatic regions of the country.
- To conduct basic and applied research on nutritional evaluation of cultivated forage/pasture species including non-conventional plants and crop residues, their conservation, fortification and utilization for optimum animal production.
- To conduct research on all aspects of forage seed production and devise suitable control measures for protecting seed during storage from diseases and pests.
- To design and fabricate efficient, low cost, labour saving farm machinery and implements from indigenous materials to meet the diverse needs with special reference to forage cultivation on small farm holdings.
- To undertake investigations on statistical de-
signs, sampling techniques and economic analysis related to herbage and seed production in forage crops/systems.

- To develop appropriate extension techniques for transfer of recommended technology, to get feedback information for further investigations and to disseminate knowledge on the subject through organised training programmes.

ORGANISATION

The Institute is organised into twelve scientific divisions, besides central units and three regional stations.

Scientific Divisions
- Plant Improvement
- Agronomy
- Grassland Management
- Agro Silvipasture
- Soil Science
- Plant Animal Relationship
- Seed Technology
- Plant Physiology and Biochemistry
- Plant Protection
- Agricultural Engineering and Post Harvest Technology
- Rural Economics and Biometrics
- Extension and Training

The nine central units are: (i) Administration (ii) Audit and Accounts (iii) Estate (iv) Farm (v) Library (vi) Technical Cell (vii) Photography and Arts (viii) Central Laboratory Services and (ix) Medical Unit. The headquater of All India Coordinated Project for Research on Forage Crops is also located at the Institute. The Institute also houses research centres of All India Coordinated Projects on (i) Dryland Agriculture (ii) Agroforestry (iii) Under utilized and under exploited plants (vi) National Seed Project. The Institute has one International Project viz. IDRC-IGFRI silvipasture operational research project.

For conducting research in various agro-climatic regions, the Institute has its Regional Station in J & K at Srinagar, in Rajasthan at CSWRI Farm, Avikanagar and in Karnataka at Tegur near Dharwar.

RESEARCH COLLABORATION

The Institute collaborates work on forage research at national and international levels. The details are as under.

All India Coordinated Research Project on Forage Crops

The project has the major mandate of formulating technical programme and monitoring of research on all aspects of forage crops at different centres in various agroclimatic regions of the country. Through this project, the Institute closely collaborates with various Agricultural Universities and Research Institutes in the country.

National Seed Project (NSP)

The World Bank aided National Seed Project located at this Institute is responsible for production of released or notified forage crops varieties.

All India Coordinated Research Project on Dryland Agriculture

The Centre of All India Coordinated Research Project on Dryland Agriculture is engaged in research based on watershed approach work for evolving suitable integrated crop production strategies for drought prone areas of the Bundelkhand region.

All India Coordinated Research Project on Agroforestry

The centre of this project is engaged in the collection and evaluation of promising fuel fodder and small timber producing species/cultivars with a view to work out suitable system for different situations.
All India Coordinated Research Project on Under-utilized and Under-exploited Plants

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

AICRP on Development, Testing Prototype Production of Farm Implements and Machinery

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

IDRC-IGFRI Silvipasture Operational Research Project

The Project aided by the IDRC Canada is on operation specifically for the Bundelkhand region with the objective of forage and tree crop productivity on degraded lands. It is being run at three sites.

SYMPOSIAS/CONGRESSES/WORKSHOPS/SUMMER INSTITUTES

2. Group Meeting of All India Coordinated Research Project for Research on Forage Crops held at IGFRI from Sept. 22-23, 1988.

STAFF

The Institute had a sanctioned strength of 245 scientific, 144 technical, 90 administrative, 174 supporting and 36 auxiliary staff. The staff position as on 31.12. 88 is given in Appendix-I.

FINANCE

During the year 1988-89, the Institute has utilized the budget grant of Rs. 202.74 lakhs of which Rs. 70.90 lakhs was utilized under plan and Rs. 132.65 lakhs under non plan. The capital expenditure was to the tune of Rs. 14.22 lakhs. During the year a revenue of Rs. 8.60 lakhs was realised. The headwise expenditure is given in Appendix II.

FACILITIES

Central Research Farm

The Institute has a total area of 574 hectares including the area under campus. Part of its area is being utilized by NRCAF for their experiments. The irrigation facilities at the farm were further strengthened although a seasonal cannaal runs across the farm.

The farm has varying topography with rakar, parwa, kabar types of soils. During the year construction of boundary wall of the farm has been initiated.

Administrative Wing and Research Laboratories

The Administrative Wing and Research Laboratories comprises of five laboratory wings and one administrative wing. It has Conference Hall, Committee room etc, which were furnished during the year. The laboratory wings have 51 sitting rooms and 25 laboratories equipped with modern instruments, fixtures and furnitures. The Central Analytical Laboratory provides centralised research services for chemical analysis and Central Instrumentation Laboratory is equipped with sophisticated electronic equipments.

Library

The Institute library procured 234 titles of books, besides the books received on complementary basis during the year. The library subscribed
for 100 Indian and 56 foreign journals. The reprographical services are also available.

Photography and Art Unit

The facility of colour work was added to the photography unit during the year. The photography and art unit undertakes the preparation of charts, maps and photographs.

Residential Complex

The residential campus named as Krishi Nagar has 132 quarters of various categories. It has also a community centre with necessary infrastructure for providing better social life to the resident. A State Government aided primary school is also available in the campus. The water supply for kitchen gardening was created during the year.

Scientist Home and Guest House

A five suite scientist home is annexed with the 13 room PG training hostel, besides, a three suite guest house which caters to the need of visitors and trainees.

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

In the year 1988, total rainfall of 815.9 mm was received in well distributed 52 rainy days (Table 1), which is 12.4% less than the normal rainfall in the region. The year experienced normal monsoon by 3rd week of June (25th standard week). The timely onset of monsoon and well distributed 719.7 mm rain throughout the monsoon season favoured crop production. The monsoon was effective for 14 weeks upto last week of Sept (39th standard week). The peak maximum temperature 47.9°C was recorded on 29th May and the peak minimum temperature 2.0°C was recorded on the 12th January, 1988.

<table>
<thead>
<tr>
<th>Months</th>
<th>Temperature(°C)</th>
<th>RH%</th>
<th>Rainfall (mm)</th>
<th>Rainy Days (no.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maxm.</td>
<td>Min.</td>
<td>Period I</td>
<td>Period II</td>
</tr>
<tr>
<td>January</td>
<td>24.5</td>
<td>6.7</td>
<td>91</td>
<td>41</td>
</tr>
<tr>
<td>February</td>
<td>29.5</td>
<td>10.5</td>
<td>83</td>
<td>26</td>
</tr>
<tr>
<td>March</td>
<td>34.7</td>
<td>15.0</td>
<td>62</td>
<td>19</td>
</tr>
<tr>
<td>April</td>
<td>40.7</td>
<td>22.3</td>
<td>52</td>
<td>19</td>
</tr>
<tr>
<td>May</td>
<td>45.2</td>
<td>29.4</td>
<td>38</td>
<td>17</td>
</tr>
<tr>
<td>June</td>
<td>39.5</td>
<td>26.9</td>
<td>62</td>
<td>39</td>
</tr>
<tr>
<td>July</td>
<td>32.7</td>
<td>25.3</td>
<td>88</td>
<td>65</td>
</tr>
<tr>
<td>August</td>
<td>33.2</td>
<td>23.3</td>
<td>89</td>
<td>61</td>
</tr>
<tr>
<td>September</td>
<td>35.8</td>
<td>24.6</td>
<td>88</td>
<td>52</td>
</tr>
<tr>
<td>October</td>
<td>34.9</td>
<td>17.1</td>
<td>85</td>
<td>33</td>
</tr>
<tr>
<td>November</td>
<td>29.8</td>
<td>10.1</td>
<td>87</td>
<td>24</td>
</tr>
<tr>
<td>December</td>
<td>25.5</td>
<td>8.3</td>
<td>86</td>
<td>33</td>
</tr>
<tr>
<td>Total</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
DIVISION OF PLANT IMPROVEMENT

PI-1: Collection, evaluation and maintenance of genetic resources in forage crops

During the year 393 collections—grasses (47), oats (102) and legumes (244) were accessioned. As a part of genetic resources maintenance programme, some of the important selections are being regenerated in isolation for multiplication of genetically pure seeds.

1.1 Grasses

(S.R. Gupta and J.N. Gupta)

Dichanthium annulatum

Forage yield and regrowth potential: Ninety one accessions representative from different habitat types and climatic zones of the country were evaluated under rainfed situations. Out of these, 19 did not survive and died at varying stages of growth. Seventy two accessions were grouped in different yield categories based on cumulative annual, monsoon yields and regrowth yields of winter and presummer seasons (Table 2). It was observed that irrespective of the place in country from where

<table>
<thead>
<tr>
<th>Yield groups</th>
<th>Yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>upto 120</td>
</tr>
<tr>
<td>Annual</td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>34</td>
</tr>
<tr>
<td>1987</td>
<td>22</td>
</tr>
<tr>
<td>1988</td>
<td>7</td>
</tr>
<tr>
<td>Monsoon</td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>28</td>
</tr>
<tr>
<td>1987</td>
<td>24</td>
</tr>
<tr>
<td>1988</td>
<td>22</td>
</tr>
<tr>
<td>Winter</td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>12</td>
</tr>
<tr>
<td>1987</td>
<td>10</td>
</tr>
</tbody>
</table>

contd....
these were collected, all collections gave maximum forage production during monsoon season. The cumulative annual yield inclusive of monsoon season and regrowth yields of winter and summer were lower in the South Indian than in the North Indian types, but former excelled the latter in the

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td>6</td>
<td>6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>11</td>
<td>09</td>
<td>09</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Characters</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Plant height (cm)</td>
<td>78.0-120.0</td>
</tr>
<tr>
<td>Leaf length (cm)</td>
<td>8.7-25.0</td>
</tr>
<tr>
<td>Leaf breadth (cm)</td>
<td>0.3-0.5</td>
</tr>
<tr>
<td>Tussuck circumference (cm)</td>
<td>30.25-42.0</td>
</tr>
<tr>
<td>Tiller weight (g)*</td>
<td>67</td>
</tr>
<tr>
<td>Habit Prostrate</td>
<td>(24)</td>
</tr>
<tr>
<td>Stem colour Red</td>
<td>(48)</td>
</tr>
<tr>
<td>Stem colour Green</td>
<td>(67)</td>
</tr>
<tr>
<td>Stem colour Yellow</td>
<td>(67)</td>
</tr>
</tbody>
</table>

*Based on number of tiller per 100 g.
( ) figures in parenthesis indicate number of accessions.
regrowth yields of winter and summer.

Variability in other growth characters: Considerable range of variability exhibited in growth parameters other than yield and regrowth potential in 72 Dichanthium annulatum accessions collected from different parts of the country (Table 3).

Effect of defoliation on tiller dynamics

Effect of defoliation on regrowth potential was studied in 42 lines of Dichanthium annulatum against three year old stand.

Tiller stage: Defoliation strongly influenced the rates of emergence of flowering to vegetative with defoliation height and within each height there was progressive decrease in ratio from rainy to summer season. Wide range of variation was also observed in response to height of cutting amongst the various genotypes during different seasons.

Tiller mortality elongation: Closer defoliation adversely affected elongation and survival of the cut tillers irrespective of genotypes and seasons. Amongst the different genotypes, both survival and elongation of tillers subsequent to defoliation increased with increased height of cutting (from 10 to 25 cm) and decreased from rainy through winter to summer season. The mortality increased from 30-45% at 25cm to more than 85% at 10 cm defoliation height. Higher defoliation heights favoured regrowth potential and minimised tiller mortality. The mortality values of defoliated tillers did not differ during different seasons.

Tillering capacity: At the base of each tiller, 6-13 buds were observed in different genotypes. Out of these 1-5 buds sprouted after one week of defoliation. The number of the buds sprouted and also their subsequent development into tiller was determined by the cutting height and genotypes differences in D. annulatum genotypes. In general, lower defoliation decreased the number of sprouted buds and their development into tillers. Nearly 80% of sprouted buds developed into tillers at higher (25 cm) defoliation. Tillering capacity was much higher as expected in these genotypes which exhibited both winter and summer regrowth after monsoon harvest compared to ones which have regrowth only in one season or have no regrowth in either of the seasons after the monsoon harvest.

Site of bud sprouting and tiller development: Of the several buds sprouted at the base of defoliated tiller only those towards the periphery of the tussock survived to develop into new tillers, while those towards the centre died out a few days after elongation. Curiously enough elongation in new tillers was more and quicker during summer season than during winter season regrowth in north Indian accession while it was almost similar in both the regrowth seasons in southern types.

Elite selections of D. annulatum: Out of the 72 marvel grass accessions studied over a period of three years, 16 were found promising which were further evaluated; On the basis of yearly pooled green forage yield IG 1997 (226.0 q/ha), 2225 (225.0 q/ha) 1985, (224.7 q/ha) were almost at par and highest yielders followed by IG 1981, 1994, 2173 and 1978. It was observed that accessions which were prostrate with platy macrophyllous leaves were very leafy having highest leaf/stem ratio (green basis) and higher yielders while semi-erect accessions ranked next. Erect types were having lower yields. All these selections had winter regrowth and forage yield varied between 19.99 (IG 1999) to 52.76 (IG 1978) q/ha.

The number of tiller per unit weight of green forage showed considerable variation during the two seasons. It ranged between 68-116 in monsoon to 410-1066 kg in winter season. In the same accession, tiller number differed remarkably i.e. from 146 to 1068 and 216 to 736 kg forage yield during monsoon and winter seasons.

Leat-stem ratio in green and dry fodder yield for winter were similar in some (IG 1978, 1979 and 192172 etc.) while deviated to a large extent in other accessions (IG 1986, 225 and 2230 etc.)
indicating the variation in per cent moisture. The data for monsoon season was almost similar for various D. annulatum collections.

The tiller length was higher during monsoon in all the prostrate types (IG 1981, 1986, 1994-95, 1997, 1999, 2004, 2169, and 2230) compared to semi-erect or erect types.

1.2 Cultivated legumes

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

Cluster bean (Cyamopsis tetragonoloba), Moth bean (Vigna aconitifolia), Vicia species, and Melilotus species collections were evaluated.

Cyamopsis tetragonoloba

Eight selections with two national check (HFG 119 and HG 75) were evaluated during the kharif. Highest green fodder yield (GFY) and dry matter yield (DM) was obtained in IGFRI 24-1 (274.1 and 72.2 q/ha GFY and DM respectively) followed by 1019-1, 212-1 and 2395-2 against the check HFG-119, having 160.6 q/ha GFY and 46.6 q/ha DM. The qualitative performance is given in table 4.

Guar variety 212-1 (Co-ordinated trial 1987)

i) For forage: The pooled result of trials conducted in various zones indicated that IGFRI 212-1 had highest GFY of 336.7 q/ha and DM (72.6 q/ha). Gt 527 (87.5 q/ha) excelled IGFRI 212-1 in DM. The checks HFG-119 yielded 280.1 q/ha GFY and 66.3 q/ha DM.

ii) For grain: Out of 23 entries tested for grain and gum (contents) production, mean gum contents percentage varied from 27.56-33.41%. The highest values obtained for check variety Naveen (33.41%) was closely followed by IGFRI 212-1 (33.23%). The letter ranked 4th and 2nd for grain yield and gum content, respectively.

At Jhansi centre, three coordinated experiments were conducted,

(i) Final evaluation trial on forage: Out of ten varieties tested, four were from the Institute viz. IGFRI 212-1, 24-1, 2395-2 and 1019-1. These were significantly superior over the check, yielding 222.6, 202.6, 217.6 and 194.0 q/ha and 58.7, 55.7, 57.8 and 73.7 q/ha DM respectively.

<table>
<thead>
<tr>
<th>Varieties</th>
<th>GFY q/ha</th>
<th>DM q/ha</th>
<th>C.P. %</th>
<th>ADF</th>
<th>NDF</th>
<th>Grain yield q/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. IGFRI-2395-2</td>
<td>257.2</td>
<td>66.8</td>
<td>15.00</td>
<td>44.12</td>
<td>50.93</td>
<td>22.6</td>
</tr>
<tr>
<td>2. IGFRI-23-1</td>
<td>216.6</td>
<td>59.3</td>
<td>14.06</td>
<td>47.32</td>
<td>55.41</td>
<td>15.56</td>
</tr>
<tr>
<td>3. IGFRI-24-1</td>
<td>274.1</td>
<td>72.2</td>
<td>10.00</td>
<td>47.94</td>
<td>57.54</td>
<td>13.86</td>
</tr>
<tr>
<td>4. IGFRI-212-1</td>
<td>262.7</td>
<td>65.1</td>
<td>14.37</td>
<td>43.83</td>
<td>43.79</td>
<td>16.36</td>
</tr>
<tr>
<td>5. IGFRI-1019-1</td>
<td>266.7</td>
<td>69.6</td>
<td>12.81</td>
<td>42.96</td>
<td>50.99</td>
<td>18.83</td>
</tr>
<tr>
<td>6. HFG-119 check</td>
<td>160.6</td>
<td>46.3</td>
<td>11.56</td>
<td>42.75</td>
<td>49.13</td>
<td>12.40</td>
</tr>
</tbody>
</table>
(ii) In CAVT-I (FET on grain): Highest grain yield was obtained from IGFRI 212-1 followed by GAUG-34 and RGC-967 which gave 20.2, 20.1 and 18.0 q/ha grain respectively.

(iii) In CIVT (IET on grain): IGFRI 2395-2 and 23-1 were found significantly superior over the better check HG-75 (15.4 q/ha) yielding 19.3 and 18.7 q/ha respectively.

**Vigna aconitifolia** (Moth bean)

Studies on 10 genotypes of moth bean were repeated during this year also. The results indicated that maximum green fodder yield was recorded in IGFRI 1202-1 (172.2 q/ha) while dry matter yield was obtained from 1073-1 (42.4 q/ha) followed by 1184-1 and 2938-1.

Among the *Melilotus* complex better yielding potentials were obtained from *M. italicca* followed by *M. alba* and *M. parviflora*. In *Vicia* species, *V. dasycarpa* was found productive over the *V. nervonensis* and *V. faba*.

### 1.3 Under exploited and non conventional plants

(J.N.Gupta, S.R.Gupta and U.P.Singh)

**Forage groundnut** (*Arachis glabrata*)

Forage groundnut, a perennial legume native of south America proliferate through rhizomes which helps in rapid colonising and form a complete cover on the ground. The plant gives palatable 951 q/ha green fodder per annum in seven cuts from April to November. Profuse leafiness of the plant is evident from the fact that leaf stem ratio was 2.15 and dry matter was 32.15% in leaves and 29.96% in stem. The plant grows well under leucaena plantation indicating their compatibility with trees and growth under shed. It also helps in suppressing the noxious perennial weeds like *Parthenium hysterophorus, Saccharum spontaneum* and *Desmostachya bipinnata*.

### Desmodium gangeticum

Evaluation of 30 indigenous accessions of *D. gangeticum* indicated a wide range of variation in different growth parameters viz. plant height (42.6-217.0 cm), branch number (5.0 - 14.0), nodes on main shoot (22.6-63.0), branch length (9.2 - 167.0 cm), leaf length (5.3 -13.1 cm), leaf breadth (3.5 - 8.1 cm), fresh weight of leaves/plant (13.1 -184.5 g), fresh weight of shoot/plant (17.5 -209.7 g) and leaf/stem ratio (0.92 -1.95.)

### Indigofera spp.

A wide range of variability and regrowth potential was observed in plant height (57.0 - 166.0, cm), number of branches (3.2 -28.3), fresh weight/plant (0.113-1.93) and leaf stem ratio (0.57:1-1.76:1) in *Indigofera* species comprising 10 prostrate and 15 erect accessions. Though erect species gave more forage but prostrate accessions were more leafy and green during summer.

### Safflower (*Carthamus tinctorius*)

In a trial of 20 selected cultivars, on the basis of forage production accession 1M 52 ranked first (342 g/plant fresh weight) followed by 1M 26-1 (328 gm/plant ) and 1M 35 (30 gm/plant). Leaf stem ratio in these selected cultivars ranged between 0.61 - 0.91.

### Rice bean

A coordinated trial was conducted with six varieties received from NBGPR, New Delhi. On the basis of grain yield A 1156 ranked first followed by IC-167-98-1 and IC 16800-1 giving the grain yield of 10.58, 5.98 and 4.82 q/ha respectively.
2.1 Breeding superior varieties of forage sorghum

(D.S Katiyar, U.S.Mishra and M.G.Gupta)

1. Germplasm evaluation

During kharif season, 272 new accessions of sorghum (Sorghum bicolor L.) 2n = 20 received from ICRISAT were evaluated. Wide range of variation (Table 5) was recorded on 214 lines only. The remaining lines showed poor germination. Out of these, 16 cultivars were isolated for further testing. Three cultivars viz. IS 938, IS 4474 and IS 3443 showed over all superiority over the control (M.P. Chari), whereas other cultivars were equivalent to control in fodder yield but superior either in leaf number or in dry matter. These cultivars took to 90 to 105 days to 50% flowering.

2. Promising strains for single cut

Eleven strains of sorghum developed through hybridisation were grown for evaluation along with HD₂ a superior strain as a check. The data on growth parameters recorded at 50% flowering stage revealed that no strain was superior for green fodder yield against the check (349.4 q/ha). However, in dry matter production the highest yield 99.8 q/ha was given by strain 1-1-3-1 as against the check 99.2 q/ha, but the difference was not significant.
3. Promising strains for multicut

12 strains of sorghum developed through hybridization were grown for evaluation along with a superior check HD2. In first cut (after 45 days) it was observed that three strains viz. D-19-2-1, I-1-3-1 and D-23-2-1 were 11, 7 and 3% superior over check (198 q/ha) in terms of green fodder yield but there were no significant varietal differences. The second cut was taken at 40 days after first cut. The cumulative (1st and 2nd cut) green fodder yield data revealed that two strains viz. I-1-3-1 and M-1-3-1 were superior recording 267 and 265 q/ha respectively over the check (263 q/ha). The varieties were significant at 5% level only.

3. Advancing of hybrid generations

F1 generation of 5 crosses was raised. One hundred and twelve F2 progenies of ten crosses were raised to study various forage contributing characters and 608 promising single plants were selected to raise F3 generation.

Similarly, one hundred fifty three F3 progenies of sixteen crosses were raised. Keeping in view the forage attributes, 430 single superior plants were selected.

4. All India testing

Institute selection J.S-3 was sent to All India Coordinated Sorghum Improvement programme for all India testing.

5. Cytogenetical studies

Hybridization was carried out by pollinating male-sterile lines of Sorghum bicolor with the pollen of desirable Sorghum species. Treatment of various doses of Colchicine for different intervals was given to various sorghum species and sorghum hybrids for induction of poliploidy.

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

(R.N.Choubey, S.K.Gupta and S.N.Zadoo)

I. FOODER OATS

1. Genetic resources: Six hundred eighteen new exotic accessions of oats obtained from the National Small Grain Collection, Maryland (U.S.A) were grown and wide spectrum of variation was observed. Several promising lines such as Orbit, Benson, Montezuma, PI 497888, PI 497819, CI 9313 and CI 9370 were found to possess desirable forage attributes. Some of the accessions were found to be susceptible for disease like bacterial leaf blight and leaf spots caused by Helmenthosporium.

2. Intervarietal hybrids and segregating progenies

A number of promising oat genotypes viz. UPO-94, Diadem, Veli, Black Mesdag, JHO-831 and JHO-851 were utilized in intervarietal crossing so as to recover desirable forage varieties.

Many promising forage genotypes were identified from F6 and F7 crosses like (06-7 x 320), (OS-6 x 320) and (OS-7 x Flemingold) for further testing. Among the F1 hybrids, JHO 831 x Diadem, OS-6 x H. Valco and JHO-831 x Cuauhtemoc exhibited excellent nicking of respective parental stocks.

3. Amphiploid progenies of A. sativa x A. maroccana

In all 145 plant progenies selected on the basis of seed fertility, tillering ability, leafiness and plant height were raised in C4 generation. There were 62 progenies of UPO-94 x A. maroccana, 75 progenies of JHO-801 x A. maroccana and progenies of OS-6 x A. maroccana crosses.
4. Back cross progenies of *A. sativa* x *A. maroccana*

The backcross derived populations grown during 1988 were 21 progenies in BC₁, 38 progenies in BC₂, and 59 progenies in BC₃. A number of promising back cross progenies viz. 398-2, 419, 420-6, 423-1 and 432-5 were identified for further testing. These progenies had normal euploid (2n=6x=42) chromosome constitution.

5. Cytogenetical studies of C₂ progenies of induced tetraploids of *Avena strigosa*

C₂ generation in induced tetraploids of *A. strigosa* was raised and studied for chromosomal stability. A sample study of 50 plants revealed an euploid, 2n= (4x) =28, chromosomal constitution of all plants. Out of these twenty plants, each representing a line were studied for cytological details. The average number of quadrivalents per cell in different plants varied from 2.6 to 4.0, trivalents from 0 to 0.05, bivalents covering about 600 cells were found to be 3.338 IV's + 0.010 III's + 7.302 II's + 0.015 I's.

The frequency of quadrivalents was found to be lower than would be expected, if the chromosomes were to associate at random. A similar frequency of rod-open bivalents in diploids and induced tetraploids indicated that rod bivalents hardly have a role in formation of quadrivalent associations. The ring/closed bivalents on the contrary may remain as such or may be failure of all ring bivalent associations appears to be due to interference caused by a cross over for realization of another crossover in near proximity, as all other factors, responsible of lower quadrivalent associations, in induced tetraploids like localized chiasma formation and preferential chromosomal pairing at tetraploid level can be ruled out in *Avena strigosa*.

6. Initial varietal trial

Eleven exotic oat genotypes were evaluated for multicut system. The released multicut variety, UPO-94 was used as the check (Table 6).

7. Development of new strains

Based on the superior performance of promising oat selections with respect to forage yield, three new multicut oat strains viz., JHO-864, JHO-865 and JHO-866 were identified for testing in All India Forage Coordinated Project. These varieties, yielded 600 and 595 q/ha green forage respectively compared to check UPO-94 (495/ha).

8. Varietal testing under All India Coordinated Project for Research on Forage Crops

The oat strains JHO-827 and JHO-831 for single cut and JHO-842 and JHO-85 for multicut were tested in initial evaluation trials. Similarly strains JHO-813, 817 825 and 826 for single cut and JHO 829 and 841 for multicut were tested in final evaluation trials of All India Coordinated Project.

II. NAPIER-BAJRA HYBRIDS

1. Development of new hybrids

Three new napier (*Pennisetum purpureum*) accessions viz., Malavi, Tanzania and Sudan were procured from ICRISAT, Hyderabad. All the three napier lines possessing desirable forage attributes were utilized in crossing programme with a new male sterile line Pb 405 A' of bajra obtained from Punjab Agril. University, Ludhiana so as to recover promising forage napier-bajra hybrids with superior yield and quality.

2. Varietal testing under All India Coordinated Forage Project

In all four new napier-bajra hybrids developed at Jhansi viz. BN 86061, BN 86073, BN 86089 and BN 86048 and a trispecific hybrid D-379 obtained from Georgia (U.S.A.) were put into test in initial evaluation trials. BN 86089 and BN 86061 had highest green forage yield to the tune of 122.4 q/ha.
and 104.4 q/ha in first and second cut, respectively. They also maintained their superiority in dry matter yield.

2.3 Breeding superior varieties of fodder maize

(G.P. Shukla)

1. Selection programmes towards population improvement

A fourth cycle of modified mass selection was completed in African tall. About 200 single plants selected at the silk stage were allowed to intermate. Their seeds were collected.

2. Co-ordinated trial

Out of the entries, Palampur local, African tall, GBM 84-2, GBM-85-3 and Jhansi AT1/89, Jhansi AT1/89 was the best forage yielder (166.6 q/ha) followed by Palampur local (119.4/qha).

PI-3: BREEDING SUPERIOR VARIETIES FOR CULTIVATED FODDER LEGUMES

3.1 Breeding varieties for high fodder yield and quality in cowpea

(K.S. Kholi and C.B. Singh)
1. Germplasm evaluation

304 cowpea germplasm material was grown during kharif 1988, out of which only 289 germinated. It was observed that out of 289 cultivars, 196 had erect growth habit. Wide variation was observed in plant height (40-190 cm) and most of the cultivars (159) fell in the height group of 66 to 115 cm. The length of the main branch varied from (30 to 125 cm) with the majority of the cultivars (198) falling in the group (30 to 75 cm). The number of branches per plant ranged from 1-9. It was also seen that out of 298 cultivars, 42 were early types with 45 to 53 days for 50% flowering, while only 14 cultivars were late types, i.e. taking 87 and above days for 50% flowering.

Most of the cultivars were erect (196) in growth habit having a medium range of height (66 to 140 cm), early to medium range for 50% flowering (45 to 61 days and 62-85 days) respectively and low branching i.e. to 5 branches per plant.

2. Advanced progeny trial

Eight cowpea selections made from F$_6$ progenies were evaluated for fodder yield. Wide range of variability was observed in green fodder yield per plant (211-297 g). The coefficient of variation was low for days to flowering (4.32%); leafiness percentage (9.23%), height of plant (16.74%), green fodder yield per plant (17.39%) and green fodder yield in q/ha (19.96%) but was high for number of branches per plant (33.93%) followed by length of the main branch (20.7%).

3. Initial evaluation trial

The initial evaluation trial in cowpea was conducted with fifteen entries. The control variety used was EC 4216. Wide range of variability was observed in growth parameters viz. plant height (107 to 170 cm), length of the main branch (66-164 cm), green fodder yield per plant (134-225 g), leafiness percentage (35-49.8%) and days to 50% flowering (46 to 81.6 days). Maximum number of cultivars (10) fell in the highest fodder producing range i.e. (126-239 q/ha) green fodder yield. The coefficient of variation for days to 50% flowering was low (10.25%) followed by green fodder yield in quintals per hectare (14.84%), whereas the coefficient of variation was higher for the remaining characters viz. leafiness percentage (19.56%), number of branches per plant (28.04%), plant height (25.87%), green fodder yield per plant (33.63%) and length of the main branch (36.14%). The control variety EC 4216 was inferior to most of the entries in yield and other characters.

4. All India coordinated yield trials

i) Final evaluation trial in cowpea (KBT-1) : Six entries were found superior yielding IFC-8401 (325.1 q/ha); IFC-8402 (290.0 q/ha); IFC 8503 (269.7 q/ha); IFC-8501 (255.6 q/ha) and UPC 4200 (248.1 q/ha) green fodder over the check UPC 5287 (190.8 q/ha).

IFC 8401 was significantly superior to all the entries while IFC 8402 ws comparable to IFC 8403, IFC 8503, IFC 8501 and UPC 4200.

(ii) Initial evaluation trial: Entries IFC-8601 (304.5 q/ha), IFC-8602 (295.5 q/ha), C.S.-34 (246.7 q/ha) and C.S.-44 (235.6 q/ha) were significantly superior to the check UPC-5287 (135.5 q/ha).

The variety IFC-8401 has given good performance for the last two years in the final evaluation trials of the co-ordinated project followed by other entry of the Institute (IFC 8402).

5. Advancing hybrid generations

The F$_2$ seeds of the 10 hybrids made in 1986 were sown and each hybrid at least 15-20 plants selections were done on the basis of earliness, erect growth habit etc.

3.2 Strain building in lucerne for yield and persistence

(C.B. Singh and K.S. Kohli)
1. All India coordinated trials

Final evaluation trial comprising of seven entries were evaluated in a replicated trial. Significant varietal differences were observed for the green fodder yield in each of the two cuts taken this year. Amongst all the varieties tested Anand-2 (control) significantly out yielded all other varieties by giving 180 q/ha green fodder yield in two cuts followed by LL Comp 6 (133 q/ha) and T-9 (129 q/ha).

2. Final evaluation trial

This was a trial with 8 elite selections. The varietal differences in the green fodder yield were non significant in any of the two cuts. The over all performance of the varieties 94-1411 (163.2 q/ha), IL 4062 (169.7 q/ha) and IL 1288 (163.2 q/ha) was much superior than the control variety IL 244 (139.9 q/ha) in two cuts.

3. Preliminary evaluation trial

This trial comprised seventeen varieties. The varietal differences in the green fodder yield were non significant in any of the two cuttings. The maximum green fodder yield was obtained in variety IL 440 (273.9 q/ha) followed by IL 248 (259.45 q/ha), IL 439 (235.62 q/ha) in two cuts as compared to IL 244 with only 228.9 q/ha.

Two varieties of lucerne were entered this year into All India Coordinated Trials by this Institutes.

3.3 Genetic improvement of Trifolium sp. with special reference to Egyptian clover

(G.P. Shukla and D.R. Malaviya)

Berseem (Trifolium alexandrinum L.)

1. Development of multifoliate berseem

Eighteen multifoliate plants were selected in 1986-87 and was felt that if, some how, this character can be established, a direct 66% increase on total foliar yield can be achieved in berseem. The selected multifoliate plants were grown along with 18 multifoliate lines. A total of 5039 plants were observed for multifoliate character and 80% plants showed strictly trifoliate nature. The pentafoliate, quadrifoliate, penta/quadrifoliate, tri/quadrifoliate and tri/pentafoliate plants were only 2%, 0.3%, 4%, 8% and 4% respectively whereas their presence in control population of var. Wardan was only 0%, 0%, 0.4%, 4.0% and 0.2% respectively.

2. Identification of bivarietal blends

The studies is a set of 7 parent bivarietal mixtures in n (n-1)/2 combinations concluded average effects of the parents to be at par. The specific effects, however, for three equiproportional mixtures viz (UPB 101 + JHB 146), (UPB 101 + JHB 37) and (UPB 101 + JHB 220) were found to be advantageous for leaf stem ratio (Table 7).

3. Preliminary yield evaluation trial

Out of 20 promising entries a set of five entries JHB 199P3, JHB 182P2, JHB 69-P3, JHB-57-P3 and JHB 183-P1 excelled the check (Wardan) by a considerable margin.

4. Mutation breeding

F1 material of two entries JB3 and BL 10 treated with gamma rays for 50, 75, 100 and 125 kR were grown. Results indicated marginal variations for inter and intra plot treatments for 125 kR selections. Selections therefore, were made in BL 10 and JB 3 within this radiation dose.

5. Selections

Selections were made on single plant oriented as well as line based. Line based selection were particularly useful for further testing for inclusion in coordinated trials. Single plant selection were made in 366 progenies out of which299 were homogenous and 67 segregating progenies for dif-
different characters.

6. Entries in All India coordinated trial

One entry JHB-ISB 86 topped the entire list at all India level for forage production in IET and, therefore, promoted to FET. Five new entries namely JHB 199-P3, JHB 182-P2, JHB 69-P3, JHB 57-P3 and JHB 183-P1 have been entered in the IET of All India Coordinated Research Programme.

vii) *Trifolium* spp.

An experiment in *T. resupinatum* L. consisted of 16 gigantic varients and 4 populations of exotic introductions and a sample population for Egyptian clover. Results indicated the means for stem girth (mm), stem length (cm), main branches/plant and the leaves per plant of the variants to be greater as compared to respective means of Egyptian clover and exotic shaftal as the 't' values were found to be significant.

3.4 Breeding high yielding fodder varieties in field bean (*Lablab purpureus*)

(D.N. Singh and S.N. Tripathi)

1. Screening of the genetic stocks

Detailed observations on germplasm collection (178) comprising new segregants, advanced hybrid progenies and new entries were recorded in separate plots. Desirable genetic lines particularly early types with fast growth rate were identified. Two of the genetic lines were very early. They took about 65 to 75 days for flowering.

2. Advanced varietal trial

Observations on 15 cultivars developed under
this project at different stages of the plant growth showed significant varietal differences. The results are:

i) **Flowering:** Data showed that cultivars were highly diverse in their initiation, 50% and 100% flowering stages. They required 101 to 122 days, 105 to 134 days and 108 to 142 days to reach these stages respectively. It exhibited that cultivars took longer time from initiation to 50% flowering than 50% to 100% flowering. On the basis of the period required, those cultivars were grouped in four classes namely, early (2), medium (8), medium late (1) and late type (4). Early cultivars exhibited highest order of synchrony in their flowering while reverse was the case with late types. Cultivars S-84 and S-31 which were early in flowering initiation took 4.6 and 7.0 days period to reach its 100% flowering respectively. Two of the early cultivars viz. S-29 and S-23 also took relatively long period to reach 100% flowering stage hence they are placed in medium group.

ii) **Leafiness (%)**: A highly important forage attribute was measured on different dates with an interval of 15 days after 3 months age which covered pre to post flowering stages of the plants. Cultivars exhibited wide variability for this character (23.9 to 40.5). They possessed maximum leafiness just before 50% flowering. At the age of 105 days, plants possessed maximum leafiness (36.1%). Late cultivars viz. IGFRI-S-1649, S-2214, S-13 and S-33 exhibited longer persistancy for leafiness while early types showed fast defoliation just after flowering.

iii) **Yield:** Data on green fodder yield on 5 dates with an interval of 15 days after 3 months age exhibited that cultivars differ significantly in their yield. Highest variability occurred on 105 days stage of the plant. Yield showed strong positive association with age of the plant. However, this association became weak after 120 days. This might be due to the simultaneous loss in leaves after flowering. On plot based data, the fodder yield ranged between 98.8 to 309.5 q/ha. Highest yield was obtained from variety S-32 followed by S-27 (247.4), S-836 (231.7) and S-2216 (219.8) q/ha.

iv) **Dry matter (%):** It was estimated on three different dates i.e. 90, 105 and 120 days after sowing which covered the entire flowering period of the plant. On an average dry matter in plants ranged between 25.5 to 27.8 per cent. Three months old plants had 25.5 per cent dry matter in fodder which increased slowly up to 120 days. However, on these stages there was no significant varietal differences. Highest dry matter was present in cultivar S-35 followed by S-836 and S-84.

### 3. Gamma-irradiation studies

Healthy uniform sized seeds of field bean cv. S-2216 and S-32 treated with different doses of gamma rays varying between 10 to 60 krad with an interval of 10 units were sown for germination in petri dishes (at room temp) as well as in the field along with the controls. Data on seed germination (%), seedling growth rate, root/shoot length on 6th day after sowing, number of M₁ plants in flowering stage and pollen attributes, exhibited differential response to the irradiation doses between and within the variety. Cultivar S-2216 was found to be more sensitive to the irradiation doses. Lowest dose (10 krad) favoured M₁ plants stand in the field as compared to higher doses as well as their respective controls. Similarly it also initiated seed germination 12 to 18 hrs early than the control, which revealed that quick germination in seeds having 10 krad irradiation might be the reason for fast root establishment in the field which later on favoured plant growth by escaping soil moisture stress in root zone of the plant in its early stage.

Advance effects shown by higher doses regarding survival of the plants in the field as well as root/shoot growth in laboratory condition clearly indicated that retarded root growth might be the cause for poor plant stand in the field. In pollen size, variation was occurred to have been induced in both the directions, i.e. there was an increase as
well as decrease in their size. Pollen fertility was also adversely affected by higher doses in both the cultivars. Result showed that doses beyond 20 krad and 30 krad were the lethal dose (LD_{50}) for varieties S-2216 and S-32 respectively. Remaining plant characters treated as well as controls behaved similarly.

4. Selection in advanced hybrid populations

F_{4} progenies belonging to cross-S-1649-1 x S-33 were relatively more tolerant to frost. Similarly F_{4} progenies plots of the cross S-22 x S-16 looked drought and frost escaping being early in maturity. Promising lines in both the populations were identified.

5. Varieties under coordinated trial

Three newly developed strains viz. JLP-31, JLP-29 and JLP-836 making a total nine entries were evaluated under All India Coordinated Forage Research Project.

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

4.1 Varietal improvement for forage yield and quality in range grasses

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

i) Dicanthium species: On the basis of pooled yield data of four cuts during second year of growth, IGFRI-585 was found superior amongst the ten strains, giving 282.0 q/ha green and 101.8 q/ha dry matter yield. The other strains such IGFRI-2058 (246.9 q/ha green and 87.7 q/ha dry), 19 A (246.4 q/ha green and 83.8 q/ha dry) and IGFRI-495-1 (228.7 q/ha green and 79.1 q/ha dry) revealed considerable superiority over the control. Marvel 8 (204.6 q/ha green and 72.3 q/ha dry). The strain IGFRI-585, 19 A and IGFRI-495-1 showed superiority consistently over two years. Significant differences were observed amongst the varieties in cut wise as well as on pooled basis also.

ii) Cenchrus ciliaris: Ten strains including IGFRI-3108 (check) of C. ciliaris were studied for their forage production potential in second year of growth. Analysis of pooled yield data of three cuts revealed that there were significant difference amongst the variety in each cuts as well as on pooled basis. It was also observed that the strain IGFRI-679 was found superior, producing 520.0 q/ha green forage as against IGFRI-3108 (507.7 q/ha). However, in dry matter production, strain IGFRI-678 was found superior (163.5 q/ha) over the check (161.6 q/ha).

IGFRI-3108 of C. ciliaris, was recommended for release during the year by All India coordinated forage workshop. Two strains were entered in All India Coordinated Research Project trials for multilocational testings.

iii) Cenchrus setigerus: Seven promising selections in C. setigerus were tested for their second year’s production ability. Analysis of pooled yield data of three cuts revealed that IGFRI-4055 was the best strain producing 407.8 q/ha green forage as against the check IGFRI-76 (396.9 q/ha). On the basis of dry matter production, strain IGFRI-4055 and IGFRI-77 was found superior, yielding 112.2 q/ha and 108.1 q/ha respectively against the check (105.1 q/ha).

4.2 Breeding superior varieties of range legumes for the improvement of pasture

(C.B. Singh and S.N. Tripathi)

Seeds collected from trispecific F_{3} hybrids (Atylosia albicans x Atylosia scarabaeoides) x Atylosia cajanifolia were grown to raise the F_{3} plants. The segregating progenies have been observed for various morphogenetic characters. The trispecific F_{3} plants showed varieties of growth forms viz., erect, semi erect, semi erect-spreading,
semi erect with branch ends drooping along with
determinate and indeterminate types. Variation in
pod shape/size, length of branches, flower colour,
leaf shape/size, leafiness and genuine plants vigour
have been marked. The plants in F₃ progenies
having high leafiness, high pod formation and
apparently high biomass yield types have been
selected for further study. F₃ plants showing moder­
te pollen fertility have been isolated for onward
 generation population study.

PI-5: PHYLOGENETIC STUDIES IN FOR­
AGE AND PASTURE SPECIES

5.1: Cytogenetical studies in cultivated leg­
umes

(S.N.Tripathi)

1. Crossability of Cajanus cajan with Atylosia spp.

Out of seven species of Atylosia, A. cajanifol­
ia, A. lineata, A. albicans and A. scarabaeoides were successfully crossed with Cajanus cajan only
when these were used as female parent, as the
reciprocal crosses were not successful. However,
two crosses of C. cajan using A. millis and A. grandifolia as pollen parent resulted in normal pod
development, but seeds from these two crosses
were extremely shrivelled and did not germinate.

The cross of Cajanus cajan using A. sericea as
pollen parent was successful.

The number of crosses made ranged from 56
(C. cajan x A. sericea) to 200 (A. cajanifolia x C.
cajan) and the per cent success ranged from 0.5 (A.
scarabaeoides x C. cajan) to 12.5 (A. cajanifolia x
C. cajan). The wild Atylosia spp. attract much at­
tention as valuable gene pool for the improvement
of cultivated Cajanus cajan. The one way cross
compatibility as noticed among Cajanus and Aty­
losia spp. appears to be on account of active bar­
rier at post fertilization stages.

2. Trispecific hybrids in Cajaninae

Seeds obtained from trispecific F₁ hybrid (C.
cajan x F₁ of of A. albicans x A. scarabaeoides) were grown to raise F₂ plants. The Cytomorpho-
genetic characters of selected F₂ plants are sum­
marised in table 8. The trispecific F₁ hybrid had
erect spreading habit. In the F₂ segregating progeny
of this hybrid, plants with different growth habit
viz., erect, erect spreading, spreading, semi erect
twiner and viny were scored. It is inferred that the
genetic constitutions of these diverse species are
able to work together to produce mature plants.
This has helped in successful transfer of useful
characters amongst Cajanus- Atylosia species by
way of gene exchange.

5.2 Cytogenetic studies in range legumes

(S.N.Zadoo)

1. Induced tetraploids

i) Macroptelium atropurpureum cv. Siratro:
Keeping in view the reduced seed setting in tetra­
ploid strain of Siratro, the diploids and induced
tetraploid subjected to 10,20, 30, 40, 50 and 60
krad doses of X-rays from Co₆₀ source, with a view
to induce cryptic structural changes for effecting
allopolyploidisation in latter and raising allopol­
yploids in the former. Cytological investigations
revealed the occurrence of gross structural changes
in higher doses. No significant improvement in
pod/seed setting was observed in any of plants
-treated with X-rays. A study of pollen sustainab­
ility in various individuals of treated induced tetra­
ploids revealed a variation from 30.83% to
85.81%. The percentage stainability was directly
related to the radiation dose applied.

A similar trend was observed in treated dip­
lloid plants also. Some of diploids with lower per­
centage of fertility have been selected/isolated for
raising tetraploids.
Table 8: Cytomorphogenetic characters of selected F2 Plants (No. of PMC’s studied were 30 for each plant)

<table>
<thead>
<tr>
<th>Characters</th>
<th>F2’s (Plant Nos)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Growth habit</td>
<td>Erect</td>
</tr>
<tr>
<td>Leaf shape</td>
<td>Lanceolate</td>
</tr>
<tr>
<td>Leaf surface</td>
<td>Coarse</td>
</tr>
<tr>
<td>Nature of stipules</td>
<td>Fugacious</td>
</tr>
<tr>
<td>Nature of petals</td>
<td>Deciduous</td>
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<tr>
<td>Colour of standard petal</td>
<td>Yellow</td>
</tr>
<tr>
<td>Days to flowering</td>
<td>110</td>
</tr>
<tr>
<td>Nature of mature pods</td>
<td>Non shattering</td>
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<td>Beak of the pods</td>
<td>Prominent</td>
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<td>Seeds/pod</td>
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<tr>
<td>Seed wrinkling</td>
<td>Absent</td>
</tr>
<tr>
<td>Pollen fertility (%)</td>
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</tr>
<tr>
<td>Av. Chromosome associations at M-1</td>
<td>10II+21</td>
</tr>
</tbody>
</table>
Rhynchosia sublobata: Three $C_1$ plants of *Rhynchosia sublobata* which were raised from a single pod by cytochimeral branch in 1987-88, did not set any seeds, despite showing a reasonably good percentage of pollen stainability (70 to 80%). The tetraploids were observed to be shy flowering types, with some physiological constraints and no seed setting. Even if all the flowers set pods and in turn seeds, the species will not be able to compete in range conditions, where high seed setting is a must for survival. Attempts made to cross the tetraploids with new established synthetic autotetraploids of *Atylosia scarabaeoides*, with former as pollen parent did not yield positive results.

**iii) Atylosia scarabaeoides:** $C_2$ progenies of 16 lines of induced tetraploids of *Atylosia scarabaeoides* were raised for selection of fertility/seed bearing ability/plant vigour. These include the erstwhile selections AT 8513, AT 8513-S, AT 8434, AT 8425 and 8425-S. Individuals with higher fertility within the selected lines are being identified for high fodder yield coupled with high seed yield.

**iv) Stylosanthes species:** Ten species of *Stylosanthes* procured from Australia were grown for preliminary cytological studies. These included the diploids (2n=2x=20) *S. viscosa; S. guianensis*, var. Endeour; *S. hamata; S. montevidensis; S. humilis*, var. Greenvale; *S. leiocarpa* and natural tetraploids (2n=4x=40), *S. hamata* var. Verano; *S. fruticosa; S. sympodialis;* and *S. scabra* var. Sce.

Out of these, four diploid species i.e.*S. hamata* *S. humilis* var. Greenvale, *S. leiocarps* and *S. viscosa* were treated with 0.1% aqueous solution of colchicine for varying lengths of time to raise autotetraploids. Some affected plants have been isolated using morphological criteria and are being confirmed cytologically. Induced tetraploids, if any, will be used in subsequent breeding programme to work out species relationships.

2 Maintenance of interchange and tetraploid lines in Sesbania

$C_3$ generation of induced autotetraploids of *Sesbania aculeata* was raised for advancing the generation. Further selections were made for seed fertility and vigour.

$C_3$ generation of induced tetraploids of three varieties of *Sesbania sesban* i.e. var. ‘Picta’ var. ‘Sesban’ and var. ‘Bicolor’ were raised for selecting better seed yielders. No significant improvement was observed in seed yield/pod setting.

Interchange lines of *S. sesban* involving six chromosomes of the complement and *S. aculeata* involving the whole chromosome complement of twelve chromosomes were raised for advancing the generation for future genetic studies.

3 Introduction of new germplasm

Two species of *Sesbania* including the stem nodale bearing species *S. rostrata* and *S. formosa* were acquired. The former was examined cytologically and was found to be a diploid with $2n = 2 \times 12$ chromosomes.

The occurrence of twin seedlings was observed in *Sesbania formosa* which appears to be a tetraploid species on the basis of morphological features. The twin seedlings have been isolated for cytological examination.

5.4 Cytogenetical studies in range grasses

(M.G.Gupta)

Cytogenetical and pollen studies

Observations on chromosomal associations and ploidy level were studied in meiotically dividing PMCs. Ten accessions of *C. ciliaris* - PGA, Phalsama, S-4, S-7, S-8, S-9, S 8-1, S 8-2-2, S 8-2-3 and S-2-4 possessed $2n=36$ at diakinesis. The chromosomes occurred in form of quadri-, tri-bivalents and univalents in various frequencies in all the accessions. However, frequency of bivalent formation was very high in all the accessions. This
suggested their autotetraploid nature. CP-5 and S-12 showed 2n = 43 (5x-2) and S-9-1 exhibited 2n = 44 (5x-1) as their chromosome complements. Occurrence of penta-, tetra-, tri-, bi- and univalents were observed in all these three accessions. All the nine accession of D. annulatum (IGFRI 494, 495, 495-1, 495-3, 495-5, 495-6, 495-10, 496 and 497) exhibited 2n = 40 as their chromosome complement in meiotically dividing PMCs at diakinesis. Chromosomal associations in form of quadri-, tri-, bi- and univalents in various frequencies were observed in all the accessions under study with a maximum occurrence of bivalents. This indicated the autotetraploid nature of all the D. annulatum accessions under study with the basic chromosome number x = 10.

Pollen viability studies were conducted on the basis of acetocarmine stainability in C. ciliaris on D. annulatum. All the accessions in both the grass species showed low pollen viability ranging from 40-50%. The variation in size of the viable pollen grain recorded was very high in both the grasses. The pollen grain ranged from 25-75μ in diameter in both the grasses.

Embryological studies

The embryosac dissection, staining and squash methods were standardized in C. ciliaris, D. annulatum and Sorghum vulgare. Four accessions in C. ciliaris-PGA, Phalsama, S-1 and S-2 were found obligate apomictic embryologically. The apomictic embryosac exhibited 4-nucleated structures with persistant and enlarged antipodal cells. Five accessions of D. annulatum IGFRI-12, 39, 494, 495 and 495-1 and S. vulgare R-473 (apomictic line) exhibited occurrence of both apomictic as well as several embryosacs in the same ovule. However, the frequency of sexual embryosac was very low as compared with that of apomictic embryosac. In D. annulatum and S. vulgare also as in case of C. ciliaris, the apomictic embryosac was 4-nucleated while sexual embryosac exhibited the typical organization of 8-nucleate embryosac.

Progeny test

Seeds were collected from the individual plants from 25 accessions of C. ciliaris and were sown in the field. The progeny plants exhibited no significant difference from their respective parent in various morphological, reproductive and vigour parameters and thus indicated the apomictic mode of reproduction in those accessions.

Induced mutagenesis

Seeds were collected from the plants treated with EMS 0.75% and 1.0% EMS and M₂ progeny were raised. Per cent germination of healthy M₂ seeds in petridish/pots was 88.0/74.0 and 86.6/78.3 and 85.0/76.0. Seedling survival in petridish after 7 days were 98%, 100% and 96%; and in pots after 21 days it were 95%, 92% and 92% in 0.75% EMS and 1.0% EMS treatments and the control respectively. Plants raised from the surviving seedlings in the pots showed no marked difference in their morphological, vegetative and reproductive characters observed among the treatments as compared with that of the control. But the chromosomal aberrations in form of bridges, nondisfunctions and laggards and other meiotic irregularities were observed in both the treatments. The pollen grain survival was marked by reduced to 27.40% and 27.25% in both the treatments as compared with 45.60% in the control. However, range in the pollen grain size in both the treatments as observed did not vary much from that in the control.
3.1 Evaluation of varietal response of forage crops

(S.N. Tripathi)

1. Response of oat varieties to varying fertility levels under sole and mixed cropping

Treatments consisted of five oat varieties (Kent, OS-6, OS-7, JHO-816 and JHO-810) in sole and mixed cropping with senji in main plots and two fertility levels (55 kg N + 45 kg P<sub>2</sub>O<sub>5</sub> and 90 kg N + 30 kg P<sub>2</sub>O<sub>5</sub>/ha) in sub-plots in split plot design with three replications. The crop was harvested for forage after 93 days of sowing.

Oat variety OS-7 producing green forage (GM), dry matter (DM) and crude protein (CP) yields of 496, 105.8 and 6.58 q/ha in sole stand and 499, 110.4 and 9.16 q/ha in mixed cropping proved significantly superior to other varieties. There was no significant difference in green forage yields due to pure (430 q/ha) and mixed cropping (437 q/ha) of oat with senji. However, dry matter and CP yields registered an increase of 11 and 51% respectively in associative cropping. Senji, the companion legume recorded maximum yields (106 q/ha GM, 27.2 q/ha DM and 4.36 q/ha CP) with oat variety JHO-810 and the lowest with OS-6 (72 q/ha GM, 17.6 q/ha DM and 2.83 q/ha CP). Application of 90 kg N + 30 kg P<sub>2</sub>O<sub>5</sub>/ha produced significantly higher forage and CP yields (466 q/ha GM, 96.6 q/ha DM and 8.28 q/ha CP) as compared to fertilizer dose of 55 kg N + 45 kg P<sub>2</sub>O<sub>5</sub>/ha (400 q/ha GM, 87 q/ha DM and 5.48 q/ha CP). The legume component, however, yielded higher when fertilized with lower dose of nitrogen and higher dose of phosphate (94 q/ha GM, 23.7 q/ha DM and 3.79 q/ha CP).

Therefore, oat variety OS-7 may be grown mixed with senji and fertilized with 90 kg N + 30 kg P<sub>2</sub>O<sub>5</sub>/ha to obtain high yields of nutritious forage.

2. Performance of oat varieties under different cutting regimes

The treatments consisting of the combinations of three oat varieties (Kent, JHO-822 and JHO-851) and four cutting schedules were tested in randomised block design with four replications on parwa (sandy loam) soil. Basal fertilizer schedule consisted of 60 kg N + 40 kg P<sub>2</sub>O<sub>5</sub>/ha. In single cut system 30 kg N was top dressed at tillering and 30 kg N/ha at jointing stage and the crop was harvested at flowering. For double cut regime, 30 kg N/ha was applied at tillering and the remaining 30 kg N/ha was given after 1st cut taken 65 days after sowing. In three cut schedule the first cut was taken at 55 days growth and 2nd and 3rd at an interval of 40 and 35 days respectively providing 30 kg N/ha each after 1st and 2nd cutting. In four cut system the first cut was obtained after 45 days of sowing and remaining three cuts at an interval of 30 days giving 20 kg N/ha to each cut.

Among varieties, JHO-851 recorded significantly higher forage yields (519 q GM and 94.3 q DM/ha) as compared to Kent (453 q GM and 83.7 q DM/ha) and JHO-822 (467 q GM and 87.7 q DM/ha). The difference in dry matter yields of JHO-851 and 822 was, however, statistically not significant. Significantly higher green fodder (552 q/ha) was recorded under double cut as compared to other cutting schedules (443 to 474 q/ha). The highest dry matter yield of 112.4 q/ha was however ob-
tained under single cut treatment which was significantly higher than 2, 3 and 4 cutting schedules. The difference between dry matter yields with 3 (74.0 q/ha) and 4 cutting schedules (71.2 DM q/ha) was not significant. The interaction between varieties and cutting schedules was significant with respect to green forage yield. Variety JHO-851 performed better than Kent and JHO-822 under 1, 3 and 4 cut systems while in 2 cut system all the varieties were at par.

Therefore, oat variety JHO-851 holds promise for multicut system to ensure the availability of green forage over a longer period of time.

3. Response of berseem varieties to the application of phosphate with and without sulphur

Three berseem varieties (Wardan, BL-60 and JHB-137) were evaluated at three levels each of phosphate (30, 60 and 90 kg P₂O₅/ha) and sulphur (0.20 and 40 kg S/ha) in 3 x confounding design with two replications. The crop was sown in 3rd week of October and total of four cuts were obtained in a growth period of 155 days.

Berseem varieties did not differ significantly in forage yield which ranged from 706 q/ha (110.8 q/ha DM) for BL-60 to 738 q/ha (113.9 q/ha DM) for JHB-137. However, in the last cut the performance of BL-60 was significantly superior (239 q GM and 49.7 q DM/ha) to JHB-137 (192 q GM and 41.8 q DM/ha). Increasing doses of phosphate increased the production of berseem and the maximum forage yield (806 q GM and 121.9 q DM/ha) was obtained with 90 kg P₂O₅/ha. However, dry matter yields ranging between 90 and 60 kg P₂O₅ was not significant. Similarly, application of sulphur increased the forage yields significantly. On an average additional forage yields of 92 q/ha (14.7 q/ha DM) and 124 q/ha (20.2 q/ha DM) were obtained on account of 20 and 40 kg S/ha respectively.

Thus in berseem cultivation, application of 40 kg S/ha alongwith 90 kg P₂O₅/ha holds promise for realising higher forage yields.

3.2 Cultural management and fertilizer use in forage/pasture crops

(S.N.Tripathi)

1. Studies on nitrogen sources and cutting management of sorghum and their residual effect on oat

Treatments comprised all combinations of three harvesting schedules of sorghum (boot, flowering and dough stages) and four nitrogen management practices (90 kg N/ha as urea, 60 kg N as urea + 30 kg N as FYM, 60 kg N as urea + 30 kg N through subabool leaves and 60 kg N as urea) alongwith cowpea mixed with sorghum in paired row system. The experiment was conducted in randomised block design with three replicates. After the harvesting of sorghum, oat was sown with 30 and 60 kg N/ha to study the residual effect of treatments given to sorghum.

Forage yields obtained with different nitrogen management practices did not differ significantly and ranged from 379 q/ha (117.9 q DM/ha) for 90 kg N/ha as urea to 360 q/ha (109.9 q DM/ha) for the mixed crop of sorghum + cowpea fertilized with 60 kg N/ha as urea. Mixed cropping of sorghum + cowpea, however, recorded maximum CP yield (8.71 q/ha) while it ranged between 5.27 to 5.58 q/ha for other fertilizer schedules. Harvesting the crop at flowering stage registered significantly higher green forage yield of 404 q/ha than harvesting at boot (355 q/ha) and dough (363 q/ha) stages. Dry matter accumulation was, however, significantly higher (139.5 q/ha) at dough stage as compared to the early stages of harvesting. Maximum C P yield (6.84 q/ha) was obtained with harvesting at flowering followed by dough and boot stages.

The sorghum crop may therefore, be grown mixed with cowpea and fertilized with 60 kg N/ha through urea and harvested at flowering stage to obtain good yield of quality forage.
2. Effect of intercrops and nitrogen levels on fodder production of winter maize

(S.D.Gupta)

Treatments involving maize (Vijay compositive) in sole stand and intercropped in additive series with *Pisum arven*is, *Lathyrus sativus* and oat were evaluated at three levels of nitrogen (40, 80 and 120 kg/ha) in RBD with three replications.

Significantly highest green forage (607.5 q/ha), dry matter (116.7 q/ha) and crude protein (12.13 q/ha) yields, were obtained when maize was intercropped with *Tivera* (*Lathyrus sativus*) followed by *Pisum arven*is (96.7 q dry matter and 11.94 q crude protein/ha). Application of 80 and 120 kg N/ha significantly elevated green forage and crude protein over 40 kg N/ha. Maize intercropped with *Tivera* and fertilized with 80 kg N/ha produced additional dry matter of 38.9 q/ha and gave corresponding gain in crude protein over sole crop of maize receiving 80 kg N/ha.

Thus intercropping of winter maize with *Lathyrus sativus* not only increases the forage yield and quality but also economises the nitrogen to the extent 40 kg/ha.

3.4 Evaluation and standardization of practices of dryland forages including *Range* and *Pasture* grasses

1. Evaluation of different ley farming systems under rainfed conditions

(K.S.Gangwar and K.P.Niranjan)

The long term experiment has been undertaken with a view to improve the fertility of marginal and submarginal soils of dryland areas by inclusion of grasses and legumes in the rotation with grain sorghum, the predominant crop of Bundelkhand region. In all 14 rotational treatments involving *Cenchrus ciliaris*, *Stylosanthes hamata* and *Sorghum bicolor* (grain) were laid out in July 1988. The crops were planted in lines 50 cm apart and the mixture of cenchrus and stylo was sown in 1:1 line orientation. The fertilizer schedule consisted of 80 kg N + 30 kg *P*<sub>2</sub>*O*<sub>5</sub>/ha for sorghum; 40 kg N + 20 *P*<sub>2</sub>*O*<sub>5</sub>/ha for cenchrus and 20 kg N + 30 kg *P*<sub>2</sub>*O*<sub>5</sub>/ha for stylo as well as for mixed stand of cenchrus stylo.

The highest grain and stover production of sorghum was 13.10 and 64.30 q/ha respectively with mean plant height of 189.5 cm. The higher herbage production was recorded with cenchrus (32 q green and 9.65 q dry matter/ha) followed by stylo (25 q green and 6.75 q dry matter/ha). The mixed stand of cenchrus + stylo produced 36 q/ha green forage and 10.35 q/ha dry matter. The plant heights of cenchrus and stylo were 70 and 51.2 cm in sole crops whereas it was 63.5 and 41.5 cm in mixed stand respectively.

3.5 Suitability of weed control technology for forage crops in cropping systems

(S.D.Gupta)

1. Effect of weed management practices on economy of N fertilizer for forage production in maize-oat rotation

The weed control treatments comprising weeder-cum-mulcher at 2 weeks crop stage, weed free environment through hand weeding, pre-emergence application of atrazine @ 0.75 kg a.i./ha and cowpea as intercrop in additive series along with weedy check in main plots and four levels of nitrogen (0, 40, 80 and 120 kg/ha) in subplots were evaluated in split plot design with three replications.

The weed flora included grassy *Echinochloa colonum*, *Dactyloctenium aegyptium*, *Digiaria* and broad leaved (*Digera arvensis*, *Celosia argen-
All the weed control treatments effectively reduced weed population over the check. Weeder-cum-mulcher and inter-cropping with cowpea caused 60.5 and 54.8% reduction in associated annual weeds and produced significantly additional dry matter yields of 7.4 and 21.7 q/ha over check (34.3 q/haDM.), respectively. Atrazine and weed free condition improved fodder production significantly and gave 21.1 and 10.8 q/ha additional dry matter yield over check. The smothering effect of cowpea caused reduction in dry weight of weeds to the extent of 8.34 and 4.13 q/ha over check and weeder-cum-mulcher treatments respectively. Moreover intercropping with cowpea also produced bonus yield of 56.0 q/ha nutritious forage enriching maize component.

Forage yield increased as the rate of nitrogen increased but the differences between 0 and 40 and 80 and 120 kg N/ha were not significant. However, 80 kg N/ha produced significantly higher dry matter yield over 0 and 40 kg N/ha.

Intercropping maize with cowpea under 40 and 80 kg N/ha reduced weed by 51 and 59.6% and produced additional dry forage of 3.89 and 16.67 q/ha as compared to 80 and 120 N/ha under weedy check.

Thus intercropping of maize + cowpea with 80 kg N/ha produced maximum legume rich herbage and economised 40 kg N/ha avoiding its wasteful consumption by weeds.

2. Weed management techniques in M.P. Chari- Berseem rotation

Twelve treatments consisted of weedy check, hand weeding (2.2 and 4 weeks crop stage), interculture by weeder cum mulcher (2.2 and 4 weeks crop stage), pre-emergence application of atrazine @ 0.75 kg a.i./ha, pre-emergence atrazine @ 0.25 kg/ha followed by hand weeding at 3 weeks crop stage, cross sowing of cowpea @ 25 kg/ha, broadcast sowing of cowpea @ 25 kg/ha, cross sowing of sunhemp @ 15 kg/ha, broadcast sowing of sunhemp @ 15 kg/ha and weed free condition in M.P. Chari in kharif and their residual effect was assessed on berseem in rabi season. The differential weed control treatments to M.P. Chari did not bring out significant variation in herbage yield of berseem. However, maximum green forage yield (770.8 q/ha) in four cuts of berseem was recorded in plots where M.P. Chari received hand weeding treatment at two weeks crop stage.

3.6 Amelioration of forage reduction with an accent on nitrogen economy in the existing cropping systems (B.S. Sinsinwar)

1. Rice based cropping system involving fodder crops in rabi season

In rabi, six fodder crops viz, berseem, oat, senji, lucerne, barely and mustard alongwith wheat were evaluated to study the effect of these crops on nitrogen economy on following rice crop. The yields of all the preceding crops including wheat grain and straw were converted into berseem yield equivalent.

Berseem produced significantly higher green fodder yield (615.8 q/ha) as compared to all other treatments. This was followed by oat (423.4 q/ha). Lucerne, however, recorded lowest yield (218.8 q/ha).

However, significantly higher dry matter accumulation was obtained with oat (145.4 q/ha) followed by barely (138.8 q/ha) over other treatments.

In the following kharif season of 1988, rice (Jaya) was planted with four doses of nitrogen (0, 40, 80 & 120 kg N/ha). There was no significant difference in the yield of rice (grain and stover) grown after various kharif fodder crops. However, maximum grain (40.2 q/ha) and straw (63.6 q/ha) yields were recorded after berseem. The direct effect of nitrogen on grain and straw production of rice was significant as the maximum grain (52.3 q/ha) and straw (90.8 q/ha) yields were recorded with 120 kg N followed by 90 kg N (46.4 q/ha grain and
70.1 q/ha straw).

Thus, cropping system involving berseem and rice resulted in maximum productivity with yield components of 615.8 q/ha of berseem and 40.2 q/ha rice grain alongwith 63.6 q/ha straw. This was followed by oat producing 434.4 q/ha berseem equivalent and 37.4 q/ha rice grain. Mustard-rice cropping system produced lowest yields (255 q/ha berseem equivalent and 38. q/ha rice grain).

2. Wheat based cropping system involving fodder crops in kharif season

The effect of forage crops in yield and nitrogen economy of wheat was evaluated in second year. Maximum grain (38.6 q/ha) and straw (63.6 q/ha) yields of wheat were recorded in the plots sown after cowpea followed by guar and Dolichos which were at par among themselves but significantly superior over all other treatments. The lowest grain (22.0 q/ha) and straw (45.9 q/ha) yields were recorded in the plots after grain sorghum. The direct effect of nitrogen was significant on the grain and straw yields of wheat with the result that maximum grain (41.8 q/ha) and straw (66.0 q/ha) yields were obtained with 120 kg N/ha.

Maize produced significantly higher green fodder yield (635.4 q/ha) over all other treatment followed by forage sorghum (550.0 q/ha). The trend of dry matter production was, however, reverse and maximum dry matter accumulation was in forage sorghum (185.5 q/ha) followed by maize (135.5 q/ha).

3. Wheat based cropping system involving sequential and parallel fodder crops

The possibility of taking forage crop in succession and association with wheat was studied taking cowpea and sorghum as preceding crops to wheat.

The results revealed that wheat taken after cowpea recorded significantly higher grain (38.0 q/ha) and straw (57.7 q/ha) yields as compared to that obtained after sorghum (33.2 q grain and 53.4 q straw/ha). Maximum grain and straw yields were recorded with pure sowing of wheat. However, it was statistically at par with wheat + berseem or wheat + lucerne in rows but higher than remaining methods. Minimum yield of wheat grain and straw was recorded (27.6 q and 42.4 q/ha) with wheat planted in border method skipping every 4th row.

The effect of nitrogen was significant and optimum level of nitrogen (120 kg N/ha) produced higher yield of grain (33.5 q/ha) and straw (52.9 q/ha) over sub optimum level (80 kg N/ha) nitrogen (30.3 q grain and 48.9 q straw/ha). The preceding kharif crop interacted significantly with nitrogen levels to wheat crop with the result that plots sown after cowpea did not exhibit significant variation in the grain yield of wheat with optimum (38.3 q/ha) and suboptimum (36.7 q/ha) level of nitrogen. After sorghum, however, optimum level of nitrogen produced significantly higher grain (36.2 q/ha) over sub-optimum level of nitrogen (30.2 q/ha).

The grain and straw yields of wheat did not show statistical difference whether grown as pure or with fodders (berseem and lucerne). Moreover berseem and lucerne gave an additional green fodder yield of 64.1 and 10.5 q/ha respectively without adversely affecting the wheat production. The lowest grain (22.9 q/ha) and straw (45.9 q/ha) yields were recorded in the plots after grain sorghum. The direct effect of nitrogen was significant on the grain and straw yields of wheat with the result that maximum grain (41.8 q/ha) and straw (66.0 q/ha) yields were obtained with 120 kg N/ha.

Maize produced significantly higher green fodder yield (635.4 q/ha) over other treatments followed by forage sorghum (550.0 q/ha). The trend of dry matter production was, however, reversed and maximum dry matter accumulation was in forage sorghum (185.5 q/ha) followed by maize (135.5 q/ha).
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)

1. Development of irrigation schedules for promising oat varieties in relation to 'Jalshakti'

Three oat varieties (JHO-822, 825 and 829) were evaluated at three levels (0, 5 and 10 kg/ha) of 'Jalshakti' and soil moisture (irrigation at IW/CPE ratio of 0.5, 0.75 and 1.0) in a partial confounding design with 6 blocks each of 9 plots. Variety JHO-825 produced highest herbage (467.0 q green and 120.0 q dry matter/ha) and crude protein (10.58 q/ha) yields. Variety JHO-829 was next in order for both the characters but the differences were significant only for crude protein production. The water use efficiency was in the order of JHO-825 > JHO-829 > JHO-822.

Forage yield increased with increase in moisture regime and irrigation at IW/CPE ratio of 1.0 and produced significantly highest green (476 q/ha) and dry matter (109 q/ha) yields. The crude protein yield with this irrigation schedule was also highest (10.53 q/ha). However, irrigation water use efficiency decreased from 71 to 36 kg DM/ha/mm, when scheduling was frequent from a ratio of 0.5 to 1.0.

Application of 5 kg Jalshakti/ha produced highest green forage (495 q/ha), dry matter (102 q/ha) and crude protein (10.79) yields. The differences were, however, significant only in terms of crude protein. Further increase in the level of 'Jalshakti' to 10 kg/ha did not exhibit additional benefits. The maximum irrigation water use efficiency (51 kg DM/ha/mm) was also recorded with 5 kg Jalshakti/ha.

Therefore, oat variety JHO-825 holds promise and needs to be irrigated at IW/CPE ratio of 1.0 with 5 kg Jalshakti/ha for realising higher herbage yield and nutrient outturn.

2. Effect of levels and application methods of 'Jalshakti' on water use of lucerne

The polymer 'Jalshakti' characterised to absorb, retain and release water was evaluated at 4 levels (0, 2.5 5.0 and 7.5 kg/ha) and 3 application methods (broadcast, furrow placement and seed coating) taking lucerne as test crop. In all, 10 treatments were compared in RBD with three replications and 4 cuts were taken during the season. Application of 5 kg Jalshakti/ha produced significantly highest green forage (383.2 q/ha) and dry matter (107.1 q/ha) yields as compared to 2.5 kg Jalshakti/ha. Further increase in the level of 'Jalshakti' to 7.5 kg/ha did not prove beneficial. Similar trend was observed with respect to crude protein production per unit area. Jalshakti at 5 kg/ha resulted in irrigation water use efficiency of 35.7 kg DM/ha/mm against 26, 32 and 33.5 kg DM/ha/mm with 0, 2.5 and 7.5 kg Jalshakti/ha.

Furrow placement of Jalshakti produced significantly highest green (398.1 q/ha) and dry matter (107.4 q/ha) yields as compared to seed coating (361.4 q/ha green and 100.6 q/ha dry matter and broadcast (324.8 q/ha green and 95.4 q/ha dry matter) methods. The highest crude protein yield (17.9 q/ha) was also recorded with furrow placement of Jalshakti but the differences were not significant. Irrigation water use efficiency with furrow placement, seed coating and broadcast methods were (35.8, 33.5 and 31.8 kg DM/ha/mm) respectively.

Therefore, lucerne may be grown with furrow placement of 5 kg Jalshakti/ha for increased herbage yield and water use efficiency.
4.2 Soil, water and crop management practices for seasonally waterlogged soils/areas

(N.P.Shukla and Menhi Lal)

1. Studies on irrigation requirement of berseem varieties under shallow water table condition

Three berseem varieties (Wardan, JB-1 and BL-10) were evaluated at three levels each of irrigation water (40, 60 and 80 mm) and soil moisture regime (0.40, 0.55 and 0.70 atm tension) in 3\(^3\) partial confounding design with 6 blocks each of 9 plots. The water table fluctuated in the range of 34 to 97 cm upto February. Thereafter it was beyond 2 meters. The number of irrigations required for 0.40, 0.55 and 0.70 atm tensions were 8, 5 and 4 respectively. Total of 5 cuts were taken during the season. Though the berseem varieties did not differ significantly but Wardan produced the highest total green forage (1058 q/ha), dry matter (157 q/ha) and crude protein (32.1 q/ha) yields. The irrigation water use efficiency was also highest (46.2 kg DM/ha/mm) with this variety.

Irrigation at 0.40 atm produced significantly highest green forage (1090 q/ha) over 0.55 atm (1030 q/ha). The dry matter yield at 0.4 atm (160 q/ha) was significantly superior to 0.70 atm (147 q/ha) but remained at par with 0.55 atm (153 q/ha). There was a linear increase in crude protein yield from 29.9 to 33.49 q/ha with decrease in soil moisture tension from 0.7 to 0.4 atm. The water use efficiency however, decreased from 61.3 to 33.3 kg DM/ha/mm with corresponding change in soil moisture regime.

The variation in delta of irrigation water did not bring out significant change in herbage yield and crude protein out turn. However, water use efficiency decreased from 68.7 to 33.3 kg DM/ha/mm due to increase in water quantity from 40 to 80 mm irrigation.

Therefore berseem variety Wardan offers the scope of growing under shallow water table conditions. The crop may be irrigated at 0.4 atm with 40 mm water when water table recedes beyond root zone depth for maintaining crop stand and productivity.

2. Effect of different moisture regimes and fertility levels on growth and yields of crops in pure and mixed stand

The response of teosinte, sunhemp and their mixed stand was studied at 3 levels each of moisture regime (well drained, wetting/drying cycle and above saturation) and plant nutrients (30+20, 60+40 and 90+60 kg N+P\(_2\)O\(_5\)/ha). The fertilizer schedule provided nitrogen to cereal and phosphate to legume as per the treatments.

Pure stand of teosinte producing the highest green forage (386 q/ha) was at par with mixed stand of teosinte + sunhemp (381 q/ha) but significantly superior to pure crop of sunhemp (326 q/ha). The dry matter accumulation was, however, highest (102 q/ha) with sunhemp which did not differ significantly from mixed stand of teosinte + sunhemp (99 q/ha). Significantly highest green forage (395 q/ha) and dry matter (106 q/ha) yields were obtained with well drained condition as compared to alternate wetting/drying cycle (363 q/ha green and 88 q/haDM) and above saturation treatment (334 q/ha green and 80 DM q/ha) which iturn were at par between themselves. There was linear increase in herbage yields with increasing levels of soil fertility and 90 kg N+ 60 kg P\(_2\)O\(_5\)/ha produced the highest green forage (413 q/ha) and dry matter (103 q/ha). The interaction, moisture regime x fertilizer levels was significant with the result that the highest dry matter yield (124 q/ha) was obtained under well drained condition by fertilizing the crop with 90 kg N+ 60 kg P\(_2\)O\(_5\)/ha followed by 60 kg N + 40 kg P\(_2\)O\(_5\)/ha (114 q/ha). These two interactions were at par between themselves but significantly superior to others.

Therefore, mixed cropping of teosinte + sunhemp holds promise under diverse moisture re-
30

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

(N.P. Shukla and Menhilal)

1. Response of oat to nitrogen in relation to moisture conservation methods

The response of oat to 3 levels of fertilizer nitrogen (25, 50 and 75 kg/ha) and 4 moisture conservation methods (grass mulch, plastic mulch and 5 kg Jalshakti/ha along with control treatment) was studied in RBD with three replications.

Significantly highest green forage (144.4 q/ha) and dry matter (47 q/ha) yields were obtained with 75 kg N/ha as compared to 25 kg N/ha (111.7 q green and 35 q dry matter/ha). The yield differences between 75 kg and 50 kg N/ha were, however, not significant. The water use efficiency was also highest at 75 kg N/ha (26.1 kg DM/ha/mm).

Among moisture conservation methods plastic mulch produced the highest green forage (147.2 q/ha) and dry matter (48.3 q/ha) yields followed by 5 kg Jalshakti/ha (137.1 q/ha green and 43.8 q/ha dry matter). These two methods produced significantly higher forage yield over control treatment. Plastic mulch conserved maximum moisture and resulted in the highest water use efficiency of (26.8 kg DM/ha/mm).

Thus, under limited water availability condition on light soil, oat may be grown with plastic mulch or 5 kg Jalshakti/ha for efficient moisture conservation. Under such situation crop needs to be fertilized with 50 kg N/ha.

2. Agronomic evaluation of Jalshakti with pasture legumes in red gravelly soil

The efficacy of Jalshakti at 4 levels (0, 2.5, 5.0 and 7.5 kg/ha) was evaluated with 4 perennial legumes (siratro, stylo, Desmenthes sp., and Desmodium sp. in RBD with 3 replications. The green forage yield of stylo (291 q/ha) was significantly higher than siratro (229 q/ha) which in turn was at par with Desmodium (204 q/ha). The dry matter yield of stylo was also the highest (64 q/ha) and at par with siratro (60 q/ha) which was significantly higher than Desmodium.

Increasing levels of Jalshakti increased the green forage and dry matter yields significantly with the result that highest yields were registered at 7.5 kg Jalshakti/ha (282.6 q/ha green and 68 q/ha dry matter). The green forage yield at 7.5 kg Jalshakti/ha was significantly superior to 5 kg Jalshakti/ha which also differed significantly from 2.5 kg Jalshakti/ha (164.9 q/ha) and control (129.0 q/ha). The dry matter yield obtained with 5 kg Jalshakti/ha (61.0 q/ha) was at par with 2.5 kg Jalshakti/ha (53.0 q/ha) but significantly different from control treatment. Therefore, in red gravelly soil with poor moisture retentivity stylo holds promise when grown with 7.5 kg Jalshakti/ha.
DIVISION OF GRASSLAND MANAGEMENT

GM·1: ESTABLISHMENT AND MANAGEMENT OF RESEEDED PASTURES FOR THEIR SUSTAINED PRODUCTIVITY ON MARGINAL AND SUBMARGINAL LANDS

1.2 Studies on the establishment and management of Stylosanthes, Dichanthium and Cenchrus based pasture for their sustained productivity

1. Effect of management practices on the productivity of sown pastures.

(P. Rai)

Studies were continued to identify the effect of cultural and fertilizer treatments on the productivity of four range grasses viz. Dichanthium annulatum, Cenchrus ciliaris, Cenchrus setigerus and C. ciliaris x C. setigerus hybrid and a legume, Stylosanthes hamata in pure and in mixtures are summarized below.

Forage production

Grasses: Green and dry forage yield increased significantly with application of fertilizer (60 kg N + 30 kg P₂O₅/ha) and interculture + fertilizer in all the grasses over control. Increase in dry matter yield varied from 7 to 12 percent due to interculture alone and from 45 to 68 percent with interculture + fertilizer.

Maximum green (23.29 t/ha) and dry (7.68 t/ha) forage yields were obtained with C. ciliaris followed by C. setigerus for green yield (20.41 t/ha) and Cenchrus hybrid for dry matter yield (7.08 t/ha).

Legume: Effect of different treatments on green and dry forage yield was observed to be non-significant. However, the maximum green (12.67 t/ha) and dry (6.18 t/ha) forage yields were obtained with application of 60 kg P₂O₅/ha followed by application of 60 kg P₂O₅/ha + 20 kg S/ha (12.58 t/ha green and 5.76 t/ha dry forage).

Grass + Legume mixture: The green and dry forage yield increased significantly with application of 30 kg N + 60 kg P₂O₅/ha and interculture + fertilizer in all the grasses over control. Due to interculture + fertilizer, the increase in green forage yield over control varied from 34 to 52 percent and dry matter yield from 40 to 67 percent.

On an average, the maximum mixed green forage yield of 20.6 t/ha (14.9 t/ha from grass + 5.6 t/ha from legume) and dry matter yield of 8.4 t/ha (6.2 t from grass + 2.2 t/ha from legume) were recorded with D. annulatum + S. hamata followed by C. ciliaris + S. hamata (20.2 t/ha green and 7.5 t/ha dry). The minimum mixed green and dry forage were obtained in Cenchrus hybrid + S. hamata.

Data on dry matter revealed that dry matter percent was higher in D. annulatum either grown in pure stand or in mixtures as compared to Cenchrus species in all cutting.

Persistency

Data on plant population of grasses and legumes in pure and mixtures at the time of second cutting exhibited not much variation in plant population of the grasses due to different management practices either grown in pure stand or in mixtures. D. annulatum showed higher survival (98.1 percent) when grown in pure stand followed by Cenchrus hybrid (97.5 percent). In case of mixture, the higher survival of 98.8 percent was recorded in C. ciliaris followed by D. annulatum (97.9 percent). The minimum survival of 95.6 and
90.1 percent was noted in *C. setigerus* when grown in pure and mixed stand respectively. The highest plant population of 78.7 plant/m² was recorded in control plot of *Cenchrus* hybrid + *S. hamata* mixture. However, on an average 50 plants/m² was recorded in the mixture of *D. annulatum* + *S. hamata*.

**Crude protein content**

Plant samples of 3 cuttings of grasses and two cuttings of *S. hamata* were analysed separately for crude protein value. It was observed that there was no variation in crude protein content in first cutting (23.3.88) in all the grasses grown in pure stand while in mixtures slightly higher CP content was recorded. However, in 2nd (18.8.88) and 3rd (18.10.88) cuttings, application of fertilizers with or without interculture showed higher CP content in all the grasses and grass-legume mixtures. Average of 3 cuts showed that the maximum CP content of 7.3 and 7.6 percent was recorded with *C. setigerus* grown in pure stand as well as mixture with *S. hamata* respectively with treatment consisting of interculture + fertilizer. Irrespective of the treatments showed slightly higher CP content in 3rd cutting in all the grasses grown in pure stand and in 2nd cutting in case of grass-legume mixtures. The CP content of *S. hamata* was also higher with application of fertilizers (30 kg N + 60 kg P₂O₅/ha) in all the mixtures in both the cuttings. On an average, the maximum CP content of 13.9 percent was recorded when *S. hamata* was grown in mixture with *C. setigerus* in the treatment of interculture + fertilizers.

2. **Evaluation of different proportion of grass-legume seed mixtures on their establishment and production**

(P.Rai and Viond Shankar)

Studies were continued during the second year with four seed mixtures of *Cenchrus ciliaris* and *Stylosanthes hamata* in the proportion of 100:100 (4 kg/ha grass + 6 kg/ha legume), 50:50 (2 kg/ha grass + 3 kg/ha legume), 33.3:66.6 (1.3 kg/ha grass + 4 kg/ha legume) and 66.6: 33.3 (2.6 kg/ha grass +2 kg/ha legume) to understand the optimum proportion of seed mixtures of *Cenchrus ciliaris* and *Stylosanthes hamata* for better establishment and higher forage production.

Results revealed that the maximum plant population of 12,28,000 plants/ha (1,20,000 plants/ha from grass + 11,08,000 plants/ha from legume) was recorded at sowing in proportion of 100:100 which was significantly higher than other seed mixtures except 50:50 proportion. The minimum establishment of 4,83,220 plants/ha was observed in the mixture of 33.3:66.6 proportion. In all the proportions, the legume population was higher than the grass.

Data on dry forage yield for *C. ciliaris*, *S. hamata*, other grasses and other legumes + forbs revealed that there was no significant differences in the total forage yield. However, the maximum dry matter yield of 5.65 t/ha (1.99t from *C. ciliaris* + 1.89 t from *S. hamata* + 1.23 t from other grasses + 0.54 t from other legumes and forbs/ha was obtained in the seed mixture of 50:50 proportion followed by 100:100 proportion (5.60 t/ha).

Observation on plant vigour revealed that plant height did not differ significantly with different proportion of seed mixtures. However, the highest plant height of 153.4 cm was recorded in *C. ciliaris* and 96.6 cm in *S. hamata* when sowing was done in the mixture of 50:50 and 33.3:66.6 proportion respectively. The maximum number of tillers/plant (84.2) in *C. ciliaris* were recorded in the mixture of 66.6:33.3 proportion and the minimum in case of 100:100 proportion.

3. **Effect of organic and inorganic N,Azospirillum inoculation and legume intercropping on the productivity of Cenchrus setigerus**

(P. Rai and M. R. Pahwa)
The experiment was continued during the second year to study the effect of 3 levels of N (0, 20 and 40 kg N/ha) applied through urea and Farm Yard Manure (FYM) and Azospirillum applied with and without urea and FYM as well as intercropping of 4 legumes (Cajanus cajan, Lablab purpureus, Clitoria ternatea and Stylosanthes hamata) on the productivity of C. setigerus.

Results on forage production revealed significant differences in dry matter yield due to different treatments. However, the maximum dry forage yield of 7.37 t/ha was recorded in the treatment consisting of Azospirillum application + 20 kg N/ha through urea + 20 kg N/ha through FYM followed by intercropping of S. hamata (3.86 t/ha from grass + 3.48 t/ha from legume = 7.34 t/ha). Due to application of 20 kg N/ha either through urea or FYM, the dry matter yield increased by 37.3 and 31.7 percent respectively over control. Due to intercropping of legumes, the increase in dry matter yield varied from 10.9 to 80.2 percent. However, due to intercropping of C. cajan, the bonus yields of 95.5 kg/ha grain and 12.5 q/ha of fuel were also obtained. Application of Azospirillum alone did not show any beneficial effect on forage of this grass.

Highest Azospirillum counts (6.2 x 10^6 cells/g dry soil) as well as available N (210.1 kg N/ha) in the rhizosphere soil was observed in case of treatment involving 20 kg N/ha (urea) + 20 kg N/ha (FYM) and inoculation followed by combined treatment of 20 kg N/ha through urea and inoculation (Azospirillum counts 0.5 x 10^6 cells/g dry soil; available N-200 kg N/ha).

The average crude protein content in plants was found to be the highest (7.0%) with 40 kg N/ha applied through FYM (1st cut -7.1% 2nd cut- 6.6% and 3rd cut-7.3%), followed by 20 kg N through urea + 20 kg N through FYM + inoculation (Azospirillum and 6.9%) and intercropping of S. hamata (6.8%).

1.6 Evaluation of productivity of Chrysopogon and Panicum pastures under various management practices

(K.P. Niranjan)

1. Effect of nitrogen and phosphorus on the productivity of Panicum maximum (cv. Makueni).

The experiment with 4 levels of nitrogen (0, 15, 30 and 45 kg/ha) and 3 levels of phosphorus (0, 15 and 30 kg P_2O_5/ha) was laid out in the randomised block design with three replications.

Nitrogen application significantly increased the dry matter production. The dry matter production increased by 22.39, 38.02 and 80.82% over control due to application of 15, 30 and 45 kg N/ha, respectively. Phosphorus applications also gave significant response on forage yield of this grass. The maximum dry matter yield (6.33 t/ha) was recorded with the application of 30 kg P_2O_5/ha.

2. Comparative performance of legume and fertilizer on the productivity of Panicum antidotale and Brachiaria decumbens.

Panicum antidotale: Effect of legume (Stylosanthes hamata) and fertilizer application on the productivity of P. antidotale was studied through six treatments-grass alone, grass + 30 kg N/ha, legume alone, legume + 30 kg P_2O_5/ha, grass + legume (1:1 ratio) and grass + legume + 30 kg P_2O_5/ha. The maximum dry forage yield 6.97 t/ha (2.25 t from grass + 4.72 t from legume) was recorded with grass + legume fertilised with 30 kg P_2O_5/ha followed by 6.0 t/ha (1.60 t from grass + 4.40 t from legume) grass + legume without fertilizer. The minimum dry matter yield (2.29 t/ha) was obtained with grass alone.

Brachiaria decumbens: Similarly, studies on B. decumbens revealed that the maximum dry matter yield of 8.41 t/ha (3.74 t from grass + 4.67 t from legume) was obtained with grass + legume fertilized with 30 kg P_2O_5/ha followed by 7.64 t/ha from grass + 30 kg N/ha. The minimum dry matter yield (5.70 t/ha) was noticed with legume alone.

GM-2: EVALUATION, IMPROVEMENT AND MANAGEMENT OF NATIVE GRASSLANDS

2.1 Investigations on the introduction of
legumes for improvement on natural grassland

1. Studies on the effect of time and method of sowing of *Stylosanthes hamata* introduction in natural grassland

(K.C. Kanodia and S.S. Parihar)

Field studies on three methods (broadcasting, spot dibbling and line sowing) combined with four times of sowing (May end, mid June, June end and mid July) on establishment of the exotic legume *S. hamata* introduced in *Sehima* dominated grassland revealed the following salient findings.

i) **Effect of sowing techniques:** The plant population of stylo in line sown plots was significantly higher (49,614/ha) than those in the other two treatments (Table-9). There were also statistically significant differences among the other two treatments. However, the lowest of the plant population 12,083/ha was recorded in the treatment, where the legume was broadcasted.

ii) **Effect of time of sowing:** Time of sowing showed a marked effect on the establishment counts of the legume. Significantly highest plant population of stylo (52,000/ha) was recorded in the mid June (premonsoon) sown plots. This was followed by May end (summer) sowing with 22,889 plants/ha. Lowest plant population (10,000/ha) of this legume was found in the plots sown in June end (monsoon). The differences in plant population among all four treatments were statistically significant.

The comparison of plant population with regards to combined effect of time and method of sowing depicted that the maximum and minimum of populations were recorded (1,13,333 and 7,000 plants/ha in the combined treatments of line sowing during premonsoon as well as in the broadcasted during May end (summer) treatment.

Further the associative effect of stylo introduction on the dominant grass (*Sehima*) was also interesting on its number of tiller (Table 10). The high-

<table>
<thead>
<tr>
<th>Table 9. Effect of time and method of sowing of sown on Stylo plant establishment (number of plants/ha).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
</tr>
<tr>
<td>Time of sowing</td>
</tr>
<tr>
<td>S₁</td>
</tr>
<tr>
<td>S₂</td>
</tr>
<tr>
<td>S₃</td>
</tr>
<tr>
<td>S₄</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Average</td>
</tr>
</tbody>
</table>
est (96 tillers/plant) was recorded in plots with line sown stylo, as compared to the minimum (75 tillers/plant) in the dibbling plots. As regards the time of sowing it was observed that the maximum number of tillers (92/plant) was recorded in the plots with mid July sown stylo i.e. where the stylo population was minimum and the minimum number of tillers (81/plant) in treatment of May end (Table-10).

2. Studies on the performance of *Stylosanthes hamata* in natural grassland under different management practices

(K.C.Kanodia and S.S.Parihar)

Studies on the improvement of *Sehima* dominated grassland was repeated with six treatments comprising of $T_1$-control; $T_2$-stylo broadcasted; $T_3$-furrows at 1 m. intervals; $T_4$-stylo + $P_2O_5$ broadcasted; $T_5$-stylo sown in furrows (1 m apart) and $T_6$-stylo + 20 kg $P_2O_5$/ha applied initially in furrows (1 m apart).

The data recorded on the plant population of the dominant grass (*Sehima nervosum*), introduced legume (*S. hamata*), other grasses, other legumes and forbs in different treatments (Table-11) revealed that the maximum percentage composition of *Sehima* (3.04%) and stylo (3.83%) as well as their population viz. 30,667 and 38,667 plants/ha respectively were recorded in the treatment where initially the stylo + $P_2O_5$/ha was applied in 1 m apart furrows. This was followed by 32,567 plants/ha of stylo respectively in the treatment, where the legume was introduced in furrows without phosphorus, but not so in case of *Sehima* grass in this treatment ($T_5$).

Further, on comparison of the population of the exotic taxon, it was noted that it was comparatively lesser than that recorded in the previous year in all most all the treatments except in $T_3$ where fresh invasion of the exotic legume was recorded for the first time. However, the plant population

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### Table 10. Effect of time and method of sowing on *Sehima* tiller number/plant.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Methods</th>
<th>$M_1$</th>
<th>$M_2$</th>
<th>$M_3$</th>
<th>Total</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time of sowing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$S_1$</td>
<td></td>
<td>86.7</td>
<td>78.2</td>
<td>76.9</td>
<td>241.3</td>
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<tr>
<td>$S_2$</td>
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<td>107.8</td>
<td>264.3</td>
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<tr>
<td>$S_3$</td>
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<td>75.7</td>
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</tr>
<tr>
<td>$S_4$</td>
<td></td>
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<td>78.0</td>
<td>103.1</td>
<td>277.5</td>
<td>92.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>338.9</td>
<td>299.9</td>
<td>383.2</td>
<td>345.3</td>
<td></td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td>84.7</td>
<td>75.0</td>
<td>95.8</td>
<td></td>
<td>86.8</td>
</tr>
<tr>
<td>Treatment</td>
<td>S. h.</td>
<td>Other native Grasses</td>
<td>Stylo hamata</td>
<td>Other native Legumes</td>
<td>Forbs and bushes</td>
<td>Total of all spp./ha</td>
</tr>
<tr>
<td>-----------</td>
<td>-------</td>
<td>---------------------</td>
<td>-------------</td>
<td>---------------------</td>
<td>-----------------</td>
<td>------------------</td>
</tr>
<tr>
<td></td>
<td>% Compo</td>
<td>Population/ha</td>
<td>% Compo</td>
<td>Population/ha</td>
<td>% Compo</td>
<td>Population/ha</td>
</tr>
<tr>
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<td>23,333</td>
<td>36.28</td>
<td>5,90,000</td>
<td>nil</td>
<td>47.38</td>
</tr>
<tr>
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<td>1.43</td>
<td>23,667</td>
<td>20.57</td>
<td>3,96,667</td>
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<td>23,667</td>
<td>29.68</td>
<td>2,84,667</td>
<td>0.73</td>
<td>7,000</td>
</tr>
<tr>
<td>T&lt;sub&gt;4&lt;/sub&gt;</td>
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<td>26,667</td>
<td>20.37</td>
<td>4,18,000</td>
<td>0.57</td>
<td>11,667</td>
</tr>
<tr>
<td>T&lt;sub&gt;5&lt;/sub&gt;</td>
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<td>24,000</td>
<td>11.72</td>
<td>1,97,000</td>
<td>1.94</td>
<td>32,667</td>
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<tr>
<td>T&lt;sub&gt;6&lt;/sub&gt;</td>
<td>3.04</td>
<td>30,667</td>
<td>17.26</td>
<td>1,74,000</td>
<td>3.83</td>
<td>38,667</td>
</tr>
</tbody>
</table>
(composition) of other (natural) grasses and legumes during the present year have increased significantly in all the treatments as compared to those of the previous year.

As regards species dynamics in the grassland the introduction of legume alongwith phosphorus in furrows also resulted in the invasion of the highest number (47) of species of other grasses (11), other legumes (13) and forbs (21), followed by the treatment where stylo with phosphorus was initially broadcasted (40).

GM-4 : ECOLOGICAL STUDIES OF NATURAL GRASSLANDS

4.5.2 Ecological studies of grassland communities of semiarid regions for increasing plant and animal productivity-Iseilema community

(B.K. Trivedi)

These studies were repeated for third year on Iseilema laxum community at Central Research Farm of the Institute with four treatments such as T1-grazing; T2-grazing + nutrient application; T3-defoliation and T4-defoliation + nutrient application. The observations were recorded on botanical composition, plant biomass, vigour of dominant and co-dominant grasses of the community, fortnightly body weight of grazing animals, etc. These results are discussed in brief as below.

Botanical Composition- The vegetation is comprised of seven species of each perennial and annual grasses, nine legumes and eight forb species. On the basis of IVI, the order of these components/groups was perennial grasses-annual grasses-legumes and forbs.

The prominent constituent species of the community are mentioned here.

Perennial grasses-Dichanthium annulatum, Heteropogon contorus, and Iseilema laxum

Annual grasses- Alloteropsis cimicina, Digitaria pedicellatum, Panicum sp. and Setaria glauca

Legumes-Alysicarpus longifolius, A. rugosus Attylosia scarabaeoides, Cassia pumila, Indigofera linifolia and Zornia gibbosa

Forbs- Borriera stricta, Corchorus sp., Cynotis sp., Fimbristylis diphylla and Phyllanthus simoex

Keeping IVI in view, D. annulatum (41.9 and 51.7) was a dominant and H. contorus (32.8 and 40.6) a co-dominant species in T1 and T2 treatments respectively. I. laxum (59.0) was dominant and H. contorus (45.4) co-dominant in T3, while in T4 the later with 61.4 IVI and earlier with 34.1 IVI were the dominant and co-dominant grasses respectively.

Plant biomass- The plant biomass fluctuated from 322.4 to 504.3 g in T1 and T4 treatments respectively arriving to an average of 431.2 g. Maximum plant biomass was contributed by perennial grass followed by annual grasses then legumes and least by forb component of the community in all the four treatments. It is obvious from the data that nutrient application increased 39.3 and 12.2% biomass in T3 and T4 treatments respectively against T1 and T2 treatments in which no nutrients were applied. In defoliated treatments (T3 and T4) about 25% more biomass was recorded in comparison to grazed treatments (T1 and T2).

Plant vigour- Observation on seven characters viz. plant height, leaf length, leaf breadth, tussock diameter, total and effective tillers and spike length of I. laxum and D. annulatum were noted for these four treatments.

I. laxum attained the maximum plant height (131.8 ± 18.3 cm) in T3 and minimum (115.1 ± 12.8 cm) in T1 treatment where as in case of D. annulatum, minimum plant height (114.8 ± 19.1 cm) was in T1 and maximum (128.2 ± 13.5 cm) in T2 treatment. The spike length of both species remained almost unaffected under these management prac-
tices. Total and effective tillers of both species increased in defoliated + nutrient application (T4) in comparison to defoliation (T3) only. In grazing treatment no trend was observed.

Secondary production- For grazing 6 growing calves, weighing between 82-126 kg of body weight and of similar age were selected. A group of 3 calves was put in grazing paddocks (T1 and T2) separately. The animals were allowed for grazing for 10 hours (8.00 am to 5.00 pm) and the grazing continued for 91 days. No concentrate and supplemental feed was given to these animals. The animals were weighed fortnightly.

At the end of grazing, 248.9 and 328.9 g/head/day was the average increase in their body weight in T1 and T2 treatments respectively. The animals of T1 treatment showed an increasing trend in their average body weight and this gain was maximum (366 g/head/day) in late October while those of T2 exhibited average maximum gain (533.3 g/head/day) in mid September.

Average dry matter intake was 1.94 and 1.97 kg/100 kg body weight/day for the animals of T1 and T2 treatments respectively.

The studies on stall feeding of the herbage of depliated treatments (T3 and T4), shrubby vegetation, herbage quality and soil in progress.

4.6 Autecology and growth behaviour studies in different range grasses

(S.S.Parihar and K.C.Kanodia)

Seed germination studies with Bothriochloa intermedia and B. pertusa

The dispersal unit in Bothriochloa species is a diad (diaspora) consisting of two spikelets, one sessile and hermaphrodite which possess the seed (caryopsis) and the other spikelets of the diad is pedicellate and sterile (staminate). Two kinds of germination studies were made (1) with the intact dispersal unit (11) with seeds (caryopsis) obtained by dehauling of the spikelets. The following germination studies were conducted.

i) Dormancy studies: Studies on dormancy revealed that freshly collected diaspores of both the species did not germinate. However, removal of glumes enabled germination (4.3%) in B pertusa only.

ii) Effect of scarification and chemical treatments on germination of diaspores: Seven treatments were imposed on fresh and 9 old diaspores to demonstrate the nature of dormancy. The treatments were control, pre-chilling, hot water, heat, ethanol, potassium nitrate and gibberellic acid. Perusal of data in table-12 reveals that dormancy could be reduced by all the treatments except heat treatment in B. intermedia. Highest per cent germination (15.0% in B. intermedia and 27.0% in B. pertusa) was recorded with gibberellic acid. In B. intermedia, pretreatment of 9 months old diaspores did not show any variation in per cent germination while in case of B. pertusa variation in per cent germination was observed (Table-12).

iii) Effect of storage and removal of glumes on germination: Enhanced per cent germination was observed with increasing the storage periods. Loss of dormancy started after three months of storage. The increasing trend in germination was maintained upto 18 months and thereafter, decline in per cent germination was evident (Table-13).

Enhanced per cent germination of seeds (i.e. caryopsis obtained by dehusking of diaspores at three monthly interval) was recorded in comparison to diaspores (Table-13). It indicates that the removal of seeds from the enclosing glumes has an enhanced effect on percent germination. However, dehusked seeds lost viability within one year of their storage suggesting that enclosing glumes together with phenolics present in the seed enclosing glumes are vitally important for restoring the viability of seeds for a longer period of time. Since, intact dispersal unit remains potentially viable for
Table-12: Effect of scarification treatments on % germination of diaspores

<table>
<thead>
<tr>
<th>Treatments</th>
<th>B. Intermedia</th>
<th>B. pertusa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fresh</td>
<td>months</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>52.33 (46.37)</td>
</tr>
<tr>
<td>Pre-chilling</td>
<td>4.3 (11.90)</td>
<td>52.66 (46.34)</td>
</tr>
<tr>
<td>Hot Water</td>
<td>2.6 (7.95)</td>
<td>31.00 (34.00)</td>
</tr>
<tr>
<td>Heat</td>
<td></td>
<td>50.33 (45.19)</td>
</tr>
<tr>
<td>Ethanol</td>
<td>4.3 (11.51)</td>
<td>48.33 (44.04)</td>
</tr>
<tr>
<td>Pot. nitrate</td>
<td>2.3 (8.47)</td>
<td>52.00 (46.14)</td>
</tr>
<tr>
<td>GA₃</td>
<td>15.0 (22.27)</td>
<td>54.00 (47.29)</td>
</tr>
<tr>
<td>SEM ±</td>
<td>1.26</td>
<td>1.26</td>
</tr>
<tr>
<td>C.D. 0.05</td>
<td>5.29</td>
<td>3.89</td>
</tr>
</tbody>
</table>

Figure given in parentheses are angular values of % germination used for statistical analysis.

Table-13: Effect of storage and removal of glumes on % germination.

<table>
<thead>
<tr>
<th>Storage period (in months)</th>
<th>B. intermedia</th>
<th>B. pertusa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spkts.</td>
<td>Seeds</td>
</tr>
<tr>
<td>3</td>
<td>6.0 (14.09)*</td>
<td>17.0 (24.26)</td>
</tr>
<tr>
<td>6</td>
<td>25.66 (30.35)</td>
<td>43.66 (41.35)</td>
</tr>
<tr>
<td>9</td>
<td>55.86 (48.25)</td>
<td>76.00 (64.10)</td>
</tr>
<tr>
<td>12</td>
<td>58.66 (50.00)</td>
<td>78.00 (62.06)</td>
</tr>
<tr>
<td>15</td>
<td>57.33 (49.22)</td>
<td>75.66 (60.49)</td>
</tr>
<tr>
<td>18</td>
<td>55.33 (48.06)</td>
<td>73.66 (59.17)</td>
</tr>
<tr>
<td>21</td>
<td>41.00 (39.81)</td>
<td>56.33 (48.65)</td>
</tr>
<tr>
<td>24</td>
<td>31.33 (34.03)</td>
<td>44.99 (41.53)</td>
</tr>
<tr>
<td>SEM ±</td>
<td>0.94</td>
<td>1.33</td>
</tr>
<tr>
<td>C.D. 0.05</td>
<td>2.85</td>
<td>4.05</td>
</tr>
</tbody>
</table>

*Figures given in parentheses are angular values of % germination used for statistical analysis.
more than two years.

iv) Bioassay studies: The removal of glumes facilitate germination of seeds in both the species. Therefore, the enhanced germination of seeds as compared to diaspores, may be attributed to the removal of specific inhibitors present in the seed enclosing husk. Therefore, bioassay studies were conducted with the methanolic extract of the diaspores. Two test species viz. Desmanthus virgatus and Raphanus sativus were also used in addition to the respective grass species. The methanolic extract of both the species had inhibitory effect on per cent germination as well as root and shoot growth though inhibitory effect varied depending upon the concentration of the methanolic extract (concentration expressed as optical densities at 535 nm).

v) Isolation and characterisation of germination inhibitors: Chromatography of methanolic: HCl extract of B. intermedia diaspores on Whatman 3 mm paper indicated presence of one magenta spot. Further chromatography on Whatman No-1 with the authentic sample of cyanidin chloride indicated presence of cyanidin glycoside in the dispersal units.

Two dimensional chromatography of the hydrolysed methanolic extract of B. pertusa diaspores on Whatman 3 mm revealed presence of seven major spots. Further chromatography on Whatman No-1 paper with authentic samples indicated of p-hydroxybenzoic, vanillic, protocatechinc, p.coumaric and ferulic acids (Table-14).

<table>
<thead>
<tr>
<th>Table-14 : Rf values and colour reactions of phenolics isolated from B. pertusa</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF. (x 100) in BAW IBW 15% AA P-nitraniline Sulfanilic acid K3Fe (CN)6 Fe Cl3</td>
</tr>
<tr>
<td>OH benzoic acid 90 84 64 Pink</td>
</tr>
<tr>
<td>Suspected p-OH benzoic acid 90 84 63 Pink</td>
</tr>
<tr>
<td>Vanillic acid 84 73 83 Purple Orange Blue</td>
</tr>
<tr>
<td>Suspected Vanillic acid 83 73 82 Purple Orange Blue</td>
</tr>
<tr>
<td>Protocatechuic acid 32 30 68 Brown Buff Blue</td>
</tr>
<tr>
<td>Suspected Protocatechuic acid 32 31 68 Brown Buff Blue</td>
</tr>
<tr>
<td>p-coumaric acid 92 87 67 43 Bn. black Red</td>
</tr>
<tr>
<td>Suspected p-coumaric acid Blue 92 86 66 42 Bn. black Red</td>
</tr>
<tr>
<td>Ferulic acid 87 81 72 34 Bn. black Tan</td>
</tr>
<tr>
<td>Blue Suspected ferulic acid 87 80 72 33 Bn. black Tan</td>
</tr>
<tr>
<td>Blue</td>
</tr>
</tbody>
</table>

Solvents are: BAW, n butanol acetic acid-water (4:1:5 top layer); IBW, isopropanol-butanol-water (140:20:60); 15% AA, 15% acetic acid.
DIVISION OF AGRO-SILVIPASTURE

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

1.1 Autecology of *Leucaena leucocephala* (Lam) de Wit

(P.S.Pathak)

Spacing and growth strategy in Silvi-4

This was the 4th year of growth. At the end of December, the growth in diameter at collar (CD) and breast height (dbh) in response to plant density and rectangularity showed (Table 15) that with the increasing plant density the growth decreased. The CD was maximum at 2500/ha (2.18 cm) and the minimum (0.13 cm) at 40,000/ha. The dbh not follow the trend of CD and was maximum at 4000/ha (1.57 cm) and minimum at 10,000/ha (0.15 cm). It is evident that the CD and dbh had no common growth strategy in relation to spacing.

With increasing rectangularity at almost identical density, the growth decreased except with 3 and 4 where it showed an increase for collar diameter. In general, at same rectangularity with increasing density the growth decreased showing uniform competition from the plants within and between the rows. It was observed at all the rectangularities. Decrease in growth with increasing rectangularities upto 2.6 indicates that plant proximity in rows influenced the growth adversely. The lower densities (upto 5000/ha) showed active diameter growth rate with age at lower plant spacing.

Survival and growth compared to Eucalyptus

At the end of second year again leucaena gave low mortality compared to eucalyptus. The height growth was more in leucaena compared to eucalyptus but the collar diameter showed a reverse trend. Eucalyptus showed clearly its higher growth rate under monocrop compared to mixed cropping. Alternate plant arrangement was found to be inferior to alternate row arrangements.

Growth and production at varying densities

A five year old trial involving 5 densities viz., 5,000, 10,000, 13,333, 20,000 and 40,000 was felled during the year. In the final stand the mortality was 6.7, 6.0, 3.3, 13.3 and 4.0% respectively showing the impact of high density in maintaining population structure for longer time. Plant height and dbh were maximum at 5,000/ha and the least at 20,000. The production per tree was also affected in the same manner but peak production was at 10,000/ha followed by 5,000/ha and 13,333, 20,000 and 40,000/ha.

<table>
<thead>
<tr>
<th>Rectangularity</th>
<th>Density (no/ha)</th>
<th>Current collar diameter</th>
<th>Annual increment dbh (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2500</td>
<td>2.18</td>
<td>1.35</td>
</tr>
<tr>
<td>1</td>
<td>4444</td>
<td>2.02</td>
<td>1.14</td>
</tr>
</tbody>
</table>

Table 15: Effect of rectangularity and plant density on current annual increment of diameter during 1988

contd....
1.2 Autecological studies on some fodder trees viz, Albizia spp, Colophospermum mopane, Dichrostachys cinerea and Prosopis juliflora

(M.M.Roy)

1. C. mopane

Seed germination

Cleaned seeds of C. mopane gave better germination in controlled (temp. 27 ± 3°C) and nursery conditions (75.83% and 60-74%) over podded seeds (44-53% and 31-36%). Significant differences in germinability, germination relative index and seedling vigour index were found in one and two year old seeds of this species.

Effect of seed size on germination

Pods/seeds of C. mopane could be classified into three distinct size groups viz., large, medium and small. The range of variation in length, breadth, thickness and weight are presented in Table-16. Moisture uptake and germination studies in controlled conditions (temp 27 ± 3°C) on these groups have shown higher range of germination (78-91%) and seedling index (928.8-1386.3) in large and medium seeds as compared to small seeds (53-68% and 318.0-428.4) at 7th day count. In a seed lot average distribution of large medium and small seeds was found to be 35.6 31.0 and 33.41% respectively.

Seedling growth in different soil types

Seedlings of C. mopane raised in three soil types viz. red, black and a mixture of red and black (1:1) in nursery conditions have indicated highest average seedling biomass (9.3 g) in black soils in 4 months followed by mixed (8.7 g) and red (6.1 g). However root growth was more prominent in terms of average tap root length (68.7 cm) and average

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>1</th>
<th>1</th>
<th>1</th>
<th>1.25</th>
<th>1.33</th>
<th>1.33</th>
<th>1.5</th>
<th>1.5</th>
<th>1.66</th>
<th>1.66</th>
<th>2.5</th>
<th>2.5</th>
<th>3.0</th>
<th>4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6400</td>
<td>10,000</td>
<td>17,777</td>
<td>40,000</td>
<td>5333</td>
<td>8000</td>
<td>3333</td>
<td>13,333</td>
<td>6666</td>
<td>26,666</td>
<td>4000</td>
<td>10,666</td>
<td>5000</td>
<td>8888</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.67</td>
<td>1.11</td>
<td>0.33</td>
<td>0.13</td>
<td>0.97</td>
<td>0.86</td>
<td>1.38</td>
<td>0.94</td>
<td>1.37</td>
<td>0.93</td>
<td>1.97</td>
<td>1.24</td>
<td>1.27</td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.85</td>
<td>0.40</td>
<td>0.48</td>
<td>0.62</td>
<td>0.66</td>
<td>1.51</td>
<td>0.80</td>
<td>1.32</td>
<td>0.88</td>
<td>1.57</td>
<td>0.15</td>
<td>1.14</td>
<td>0.84</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.67</td>
<td>1.00</td>
<td>0.74</td>
<td>0.96</td>
<td>0.76</td>
<td>0.97</td>
<td>1.00</td>
<td>0.94</td>
<td>0.78</td>
<td>0.77</td>
<td>0.73</td>
<td>0.67</td>
<td>0.74</td>
<td></td>
</tr>
</tbody>
</table>
Table: 16. Range of variation in pod and seed sizes of *Colophospermum mopane*.

<table>
<thead>
<tr>
<th>Size group</th>
<th>POD</th>
<th>SEED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length (cm)</td>
<td>Breadth (cm)</td>
</tr>
<tr>
<td>Large</td>
<td>4.2-5.2</td>
<td>2.3-2.9</td>
</tr>
<tr>
<td></td>
<td>(4.61)</td>
<td>(2.59)</td>
</tr>
<tr>
<td>Medium</td>
<td>3.6-4.1</td>
<td>1.6-2.2</td>
</tr>
<tr>
<td></td>
<td>(3.70)</td>
<td>(1.90)</td>
</tr>
<tr>
<td>Small</td>
<td>2.8</td>
<td>-4.0-1.0-2.1</td>
</tr>
<tr>
<td></td>
<td>(2.97)</td>
<td>(1.70)</td>
</tr>
</tbody>
</table>

(The values in parenthesis represent average values)
number of secondary roots (9-11) in red soils. Nodulation, in general, was very poor and only in mixed and black soils a few small sized nodules were detected.

2. *P. juliflora*

Seed germination

Seed soaking of *P. fuliflora* in water for about 48 hours at Dhirpura (MP) has been found to be most effective in obtaining single segmented seeds. For efficient separation of such seeds soaking in 10% NaOH for 30 minutes followed by washing in tap water and rubbing between folds of cloth was found to be the most effective method. Clean seeds required boiling water treatment followed by overnight soaking in water for effective germination in controlled (80-85%) and nursery conditions (65-73%)

Seedling growth in different soil types

Highest average seedling biomass (18.7 g) of *Prosopis Juliflora* in 4 month period could be obtained in black soils followed by mixed (15.6 g) and red (12.2 g) soils. Significant difference in root growth and spread was not observed, however, nodulation occurred in all treatments. Highest average nodule weight was obtained in mixed soils (5.1 mg) followed by black (4.5 mg) and red (0.8 mg) soils.

3. *Albizia spp*

Biomass accumulation in *Albizia amara*

Thirteen trees of *A. amara* at 16 year age were felled for studying biomass accumulation pattern in different parts and subsequent coppicing behaviour. Average height and CD were recorded to be 930 cm and 41.35 cm respectively. Maximum biomass accumulation was in the bole (58.6%) followed by branch (33.8%) and leaves (7.6%). Highest variability in branch weight was observed (Table 17)

ASIP-2: EVOLVING SILVIPASTORAL SYSTEMS FOR VARIOUS MARGINAL AND SUBMARGINAL WASTELANDS AND ENVIRONMENT

2.3 Silvipastoral studies on some fodder trees viz., *Albizia spp, Colophospermum mopane, Dichrostachys cinerea* and *Prosopis juliflora*

(M.M. Roy)

**Table 17: Growth and biomass accumulation pattern in *A. amara* at 16th year**

<table>
<thead>
<tr>
<th>Growth</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>930 ± 167</td>
<td></td>
</tr>
<tr>
<td>Basal Diameter (cm)</td>
<td>41.45 ± 3.71</td>
<td></td>
</tr>
</tbody>
</table>

Biomass accumulation

<table>
<thead>
<tr>
<th>Part</th>
<th>Weight (kg)</th>
<th>(The values in parenthesis represent dry weights)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bole</td>
<td>491.85 ± 86.33</td>
<td>309.87 ± 54.39</td>
</tr>
<tr>
<td>Branch</td>
<td>283.45 ± 93.42</td>
<td>107.14 ± 75.32</td>
</tr>
<tr>
<td>Leaves</td>
<td>63.48 ± 17.74</td>
<td>32.37 ± 0.06</td>
</tr>
</tbody>
</table>

Sapling establishment and growth of *Albizia* and *D. cinerea* in natural grassland (2nd year)

In the 2nd year *D. cinerea* exhibited peak survival (83%) followed by *Albizia amara* (76%), *A. lebbek* (57%) and *A. procera* (28%). During this
period *D. cinerea* exhibited peak height and diameter values (126 cm and 1.46 cm) followed by *A. amara* (103 cm and 1.38 cm), *A. lebbek* (98 cm and 1.25 cm) and *A. procera* (85 cm and 1.3 cm). No significant differences in grass production in different tree combinations could be established at this stage. Average grass productivity during October/November varied from 2.2 to 3.1 t (dry) ha\(^{-1}\) yr\(^{-1}\).

2.4 Silvipastoral studies on *Dalbergia sissoo*, *Hardwickia binata* and *Acacia* species

(S.K. Gupta)

1. Evaluation of *Acacia nilotica* and *A. tortilis* on calcareous wastelands at 5.5 years

Survival of *Acacia tortilis* was higher than *A. nilotica* at age 5.5 years. In the former, alternate line management system was better whereas in the later alternate plant management system was better in respect of survival (Table 18).

Plant height was remarkably higher in alternate plant management system in *Acacia tortilis*. In case of *A. nilotica* also growth was more pronounced in alternate plant management system. Similar trend was found in growth of collar diameter and in diameter in breast height in both the species (Table 18).

Production potential of natural grasses on such land in ALM and APM system was 3.52 t ha\(^{-1}\) and 2.32 t ha\(^{-1}\) respectively. Similarly yield of stylo was 0.38 t ha\(^{-1}\) and 0.27 t ha\(^{-1}\) respectively.

2. Evaluation of *A. nilotica*, *A. nilotica* *var*. *Cupriformis* and *A. tortils* in 15 different densities.

Average growth and survival data of these species is presented in Table 19. Yield of natural grasses in association with these species was 5.86 t ha\(^{-1}\), 5.91 t ha\(^{-1}\) and 5.01 t ha\(^{-1}\) respectively.
3.2 Establishment and growth of poplar clones in the agroforestry system

(P.S.Pathak)
canopies indicates the role of ideal canopy temperature, photosynthetically active radiation and humidity during June under 3 tier growth and open in September.

3.3 Productivity of agro-silipastoral system involving *Leucaena leucocephala* and *Melia azadirachta*

P.S.Pathak and P. Rai

The experiment was laid out in July this year. Observations for production and tree survival growth are presented as under.

**Tree seedling survival:** Two tree species planted under seasonal crop of pigeon pea + sesame, natural grassland and cultivated pasture showed peak survival after 6 months of *Melia azadirachta* (100%) under crop and its lowest with natural grassland (85.7%). In case of Subabul 93.4% survival was recorded with natural grassland and its lowest (80.4%) with crops. By the end of December, no species gave less than 80.4% survival indicating a success of the plantation. Over all under improved pasture situation, the survival was lowest (86.7%) compared to crop (90.1%).

**Height growth of trees:** Average growth of Bakain was maximum (26.8 cm) with improved pasture and the minimum in rainfed crop (17.8 cm). In case of subabul the maximum (69 cm) was with natural grassland and the minimum (54 cm) with rainfed crop. This feature reflected the negative interaction with crop growth at early stage. At this early growth stage growth of tree mixtures could not be compared.

**Diameter growth:** Bakain showed maximum diameter growth (0.49 cm) with improved pasture and the minimum (0.21 cm) with rainfed crop. In case of subabul, the diameter growth with natural and improved grassland was at par and maximum (0.82) compared to 0.59 cm with rainfed crops. The poor diameter growth with fast growing rainfed crops could be attributed to the competition for light, nutrients and the aerial space.

**Production of natural grassland:** The natural grassland gave an yield of 2.94 t/ha (over dry) since it was the first year of production. this poor yield could be well expected.

**Production of improved pasture:** *Cenchrus ciliaris* planted at 50 cm x 1 m was intersown with *Stylosanthes hamata*. Being the first year, the production was only 1.32 t/ha (over dry) after the collection of seeds from the grass.

**Production of rainfed crops:** From sesame, the grain yield was 0.235 t/ha and straw 5.52 t/ha. Pigeon pea was harvested late. The yield of stick was 1.889 t/ha while the grain production was only 0.084 t/ha (low yield due to biotic damage- blue bull). Pigeon pea was sown in lines 1 m apart accommodating sesame in between.

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

4.1 Growth and productivity structure of fruit crops in association with grasses and legumes

S.K.Sharma

1. Seasonal growth pattern of fruit trees in association with grasses and forage legumes

(a) **Lemon:** High mortality was observed due to continuous drought infestation of diseases/pests and mechanical damages (mainly due to grazing). Therefore, total lemon plantation was to be replaced by locally adapted better Kinnow mandarin in July 1988.

(b) **Kinnow mandarin:** The interspacing of 6 m x 6 m was used to grow intercrops of *Stylosanthes hamata* and *Cenchrus ciliaris* and mixture of both (1:1) were grown with interspacing 6 x 6 m. Maximum plant height was obtained in control (168.12
cm) followed by trees grown with S. hamata (150.6 cm). Similarly, maximum stem girth was obtained in control (2.03) followed by trees grown with S. hamata (1.92 cm). The tree canopy was largest in control (NS 81.00 cm, EW 79.00 cm) followed by S. hamata (NS 68.00 cm, EW 63.00 cm).

(c) Guava: In the second year the better growth was obtained in the plants grown without any crops (i.e. control) than the plants grown with intercrops. Plant height was maximum in control (102.00 cm) followed by S. hamata (81.23 cm). Stem girth was higher in the control (stock 0.92 cm, union 1.12 cm scion 0.92 cm) followed by S. hamata (stock 0.92 cm, union 0.98 cm, scion 0.86 cm). The tree canopy was largest in control (NS 89.00 cm, EW 83.00 cm) followed by S. hamata (NS 73.00 cm, EW 69.00 cm).

2. Growth pattern of grasses and forage legumes

The growth structure of S. hamata and C. ciliaris was not affected significantly when grown with guava, kinnow or as mix crop except in the few cases.

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

5.1 Genetic improvement of Subabul (Leucaena leucocephala) in relation to forage and fuelwood production and quality

(V.K. Gupta)

1. Collection, evaluation, maintenance and classification of germplasm

(i) During this year, 165 provenances of genus Leucaena were procured from Oxford Forestry Institute, Oxford; Commonwealth Scientific and Industrial Organisation, Australia; and University of Hawaii, Hawaii. These provenances comprises of of L. collinsii (10), L. cuspidata (1), L. diversifolia (12) L. esculenta (4), L. gregii (30), L. lanceolata var. lanceolata (31), L. lanceolata var. Sousa (2), L. leucocephala (10), L. macrophylla (10), L. pulverulenta (4), L. retusa (10), L. salvadorensis (9), L. shannoni (21), L. trichodes (10), L. pallida (1) and two interspecific hybrids which are reported to be phyllid insect resistant. These will be evaluated in year 1989 at nursery level and also in fields.

(ii) Seven Leucaena species viz., L. diversifolia (K 156 and 78-49), L. lanceolata var. lanceolata (K 10), L. shannoni (78-40), L. trichodes (78-86), L. macrophylla (K 381), L. leucocephala (K 8, K 28, and IGFRI 23-1), L. pulverulenta (K 75) and two interspecific hybrids of L. leucocephala x L. pulverulenta were evaluated for their regeneration potential. All species under study had good regeneration ability. Total coppice yield and number of coppice per plant, in general, were correlated to the growth of 1st cycle. In II cycle again one of the interspecific hybrid (dbh 42.0 cm, no. of shoots per plant 8.88 and plant height 778.4 cm) and plus selection IGFRI 23-1 (dbh 23.2, no. of shoots per plant 5.6 and plant height 675.0 cm) were superior over K 8 (dbh 20.4, no. of shoots per plant 4.9 and plant height 643.5 cm).

(iii) Twenty seven provenances received from Mexico were evaluated for regeneration potential. All the accessions regenerated well. IGFRI 23-1 had maximum number of coppices per tree, plant height and dbh followed by IGFRI 101, IGFRI 88 and K 8 (check). None of the promising provenances flowered in 1st year.

(iv) Peak growth in term of plant height, dbh and CD was found in IGFRI199 (K 601) of subabul. This accession was better than K 8 and IGFRI 23-1, IGFRI 200 (K 614) and IGFRI 208 (K 776) of subabul were at par with K 8 for growth attributes. For seed production all the promising provenances were at par with K 8 specially in summer season.
In preliminary evaluation trial of 16 provenances of genus *Leucaena* comprising 4 provenances of *L. diversifolia*: 2 *L. pulverulenta*, 1 *L. macrophylla*, 1 *L. collinsii*, 1 *L. esculenta*, 1 *L. insularum*, 1 *L. shannonii*, 4 *L. leucocephala*, 1 *L. lanceolata* were evaluated for growth parameters and flowering period. *L. esculenta* (K 681) and *L. macrophylla* (K 381) did not flower yet. Among all the provenances, all the 4 accessions of *L. leucocephala* were superior to remaining species followed by *L. collinsii* (K476) and *L. pulverulenta* (CPI9049).

2. Interspecific hybridization programme

This year intensive efforts were made to study the degree of crossability among species of genus *Leucaena*. We got success in making crosses between *L. leucocephala* x *L. collinsii*, *L. leucocephala* x *L. diversifolia* (K 156), *L. collinsii* x *L. diversifolia* (2n = 52), *L. lanceolata* x *L. collinsii*, *L. laceolata* x *L. shannonii*, *L. shannonii* x *L. diversifolia* (2n = 52), *L. shannonii* x *L. collinsii*, *L. diversifolia* (2n=52) x *L. collinsii*, *L. diversifolia* x *L. shannonii* and *IGFRI 31* x *IGFRI 11* were found to be promising and better than K8 and K 28 varieties. Four trees i.e. BIIL 18-10, BIV L3-10, BIV L4-10 and BIV L18-9 exhibited better performance than the best plants of K8 and IGFRI 23-1.

**F2** intervarietal populations

In **F2** generation partial sterility and complete sterility were found in some of the trees. This finding has given the hope to get male sterile trees in segregating generations of intervarietal populations of *L. leucocephala*. One of the plant had few pods when there was no control over pollination but there was no pod setting in 50 flower heads after selfing. Beside these, there were nine trees which were better than K8 and IGFRI 23-1 in respect of growth characters and having low seed yields.

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

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

1. Transformation fonctions for normality of data were confirmed (Jeffers Method) and being given as below:-

   1. *Albizia amara*  
      : Logarithmic
   2. *Acacia tortilis*  
      : Logarithmic
   3. *L. leucocephala*  
      : Square root
   4. *H. binnata*  
      : Square root

   In case of *L. leucocephala*, transformation function was in between logarithmic and square root, however square root function was found in majority of cases.

2. Following equations give the optimum prediction in different species

   **Albizia amara**

   Woody biomass = -1 +0.4663 (1+dbh) ^0.485,  
   \[ r^2 = 0.884 \]
AG biomass = -1 + 0.4781 (1 + dbh)^1.4869
\( r^2 = 0.858 \)

**Acacia tortilis**

Bole biomass = 1 + 0.0059 (1 + height)^4.056
\( r^2 = 0.747 \)
Branch = -1 + 1.2783 (1 + dbh)^1.419
\( r^2 = 0.656 \)
AG biomass = 1 + 0.3071 (1 + cd)^2.045
\( r^2 = 0.648 \)

**L. leucocephala**

\( \sqrt{\text{Bole}} = -7.1241 + 4.1942 \sqrt{\text{dbh}} \),
\( r^2 = 0.927 \)
\( \sqrt{\text{Branch}} = -3.0312 + 1.8608 \sqrt{\text{dbh}} \),
\( r^2 = 0.854 \)
\( \sqrt{\text{AG biomass}} = -8.1390 + 4.7976 \sqrt{\text{dbh}} \)
\( r^2 = 0.936 \)

**H. binata**

\( \sqrt{\text{Bole}} = -6.2700 + 3.4304 \sqrt{\text{dbh}} \)
\( r^2 = 0.680 \)
\( \sqrt{\text{Branch}} = -6.3800 + 2.7431 \sqrt{\text{dbh}} \)
\( r^2 = 0.690 \)
\( \sqrt{\text{AG biomass}} = -9.4225 + 4.6555 \sqrt{\text{dbh}} \)
\( r^2 = 0.690 \)

In all the species except *A. tortilis*, prediction was optimum \( (r^2 > 0.80) \) through dbh only.

SE(b) of AG biomass with dbh for 3.5 to 7.5 year growth in *Leucaena leucocephala* were non-significant.

Predicted biomass tables were also prepared for each species.

3. Predicted equations in *Leucaena leucocephala* for two types of locations compared and regressions were differed non-significantly.

4. Farm factors for the following species were calculated.

**Leucaena leucocephala**

In this species, at different growth (age), farm factor calculated and following equation was found.

\[ \text{Farm factor} = -1 + 1.8485 (1 + \text{Age})^{0.1507} \]

**H. binata**

At the age of 14 years, the farm factor was found to be 0.3648

It is further being analysed for modelling production function for different management systems.

AG: Above ground biomass
DIVISION OF SOIL SCIENCE

SS-1: SOIL STUDIES UNDER INTENSIVE FORAGE PRODUCTION

1.2 Studies on bacterial mediated N$_2$-fixation for increased productivity in cultivated fodder crops

(M.R. Pahwa)

Inoculation with varying cell population densities of Azotobacter

In a pot culture experiment using red soil (pH-7.1), mustard seed inoculation was tried at five cell population densities (0, 1.8 x $10^6$, 1.8 x $10^4$, 1.8 x $10^6$ and 1.8 x $10^8$ cell/ml inoculum) of Azotobacter chroococcum A41. Maximum beneficial effect on green (10.2 g/plant) and dry fodder yields (1.7 g/plant) as on nitrogen concentration in plants (1.8%) was observed with the inoculum containing 1.8 x $10^6$ cells/ml inoculum.

Efficient host Azospirillum associations

The investigation was taken up in pots with a view to select genotypic compatible combination of cereal fodder cultivar and Azospirillum brasilense for improved productivity. The results are as under:

1. Of the twelve promising oat cultivars (JHO-810, JHO-813, JHO-817, JHO-822, JHO-825, JHO-826, JHO-827, JHO-829, JHO-831, JHO-841, JHO-842 and JHO-851) evaluated for their compatibility with respect to A. brasilense -ICM-1003, only six (JHO-810, JHO-817, JHO-825, JHO-826, JHO-829 and JHO-851) recorded significantly increased plant height, green and dry matter accumulation. The highest green forage yield (35% higher over uninoculated control) rich in crude protein content (8.5%) was produced by JHO-810-Azospirillum brasilense association. The rhizospheric Azospirillum count was also the highest (5.0 x $10^6$ cells/g dry soil) in case of inoculated oat cultivar JHO-810.

2. Among the seven strains of A. brasilense (A. b-ICM-1002, A.b-ICM-1003, A.b-3, A.b-SP7A, A.b-2, A.b-1 and A.b-IG-1) regard to their efficacy evaluation on fodder oat variety Kent in red soil. Inoculation with strain ICM-1003 produced significantly the highest green (28.8g/plant) and dry forage yield (6.2g/plant) as well as crude protein accumulation (0.5g/plant) over no inoculation (Green yield-21.0g, DM-4.6g and CP-0.3g/plant). Marked improvement in dry root biomass (3.2g/plant) and nitrogen uptake (81 mg/plant) by plants was also observed with the application of inoculant strain-ICM-1002

Crop response

Investigations undertaken in pots with a view to assess the potential of inoculants, applied singly or in combination revealed the following findings.

1. Inoculation with two mixed strains of Azotobacter chroococcum (A41 and ICM-2001) exhibited greater improvement in green forage yield (+35%) of barley as compared to individual strain (+15-24.4%). Lower level on N (40kg N/ha) in presence of both the strains of Azotobacter recorded the highest shoot and dry root biomass of barley (40kg N/ha-green shoot yield-38.5g/plant, dry root biomass-0.5g/plant 40kg N/ha-I-green shoot yield 54g/plant, DM 14.5g and 1.4g/plant) as well as N concentration in plants (0.9%). Similar positive effect was also noticed on nitrogen uptake by plants (130.5 mg/plant)

2. Response of lucerne to individual and combined microbial inoculation (Rhizobium meliloti
LJ-13, VAM fungi *Glomus fasciculatum*. *Bacillus polymyxa* H, indicated significantly higher nodulation (20/plant), root length (23cm/plant), total green (26.1 g) and dry forage yields (5.7g), as well as crude protein content (19%) in two cuts in lucerne on account combined application of Rhizobium and VAM fungi.

1.5 Evapotranspiration studies in forage crop through Lysimetery

(Pradeep Behari)

The daily evapotranspiration measurement of pea cv. Rachana was recorded. Total evapotranspiration of 146.4 mm was recorded during 91 days of crop growth period that gives a mean value of ET 1.6 mm/day. The green and dry matter yields of pea were 134.9 g/ha and 21.3 g/ha of Lysimeter and 79.8 g/ha and 10.9 g/ha in the remaining area respectively. The water use efficiency was calculated to be 14.55 kg. DM/ha/mm.

In kharif 1988, maize crop (vr. African Tall) was sown. Cumulative evapotranspiration was recorded during 65 days growth period with mean value of 4.9 mm/day. The green and dry matter yields of maize crop was 398.5 g/ha and 63.3 g/ha in Lysimeter and 99.3 g/ha and 15.4 g/ha in the remaining area. The water use efficiency was calculated to be 20.04 kg. DM/ha/hm.

SS-2: SOIL STUDIES OF RANGE-LANDS AND PASTURES

2.1 Studies on bacteria mediated N₂ fixation for increased productivity in pasture species

(M.R.Pahwa)

*Azospirillum* for grass species

i) Studies were continued for the second year in pots and fields to know the relative efficacy of different strains of *Azospirillum* species on grass species (*Cenchrus ciliaris*, *Cenchrus setigerus* and *Dichanthium annulatum*). Forage yields were recorded in two more cuttings. The results indicated superior performance by *Azospirillum lipoferum* strains (1,2, IG-5 and ICM-1001) in terms of total green (75.4-84.7g/plant), dry biomass yields (26.2-30.1g/plant) as well as crude protein accumulation (1.4 to 1.8g/plant) in *C. ciliaris* in four cuts as compared to seven (A.b-2, A.b-SP7A,A.b-ICM-2, A.b-ICM-1002, A.b-1, A.b-3, and A.b-ICM 1003) A.brasilense strains (green yield -67.2-71. 8g/plant, DM-23.3-25.1g/plant, C P yield -1.1 -1.3g/plant). Maximum beneficial effect was obtained by *A. lipoferum* l (green yield-84.7g/plant, D M 30/g, dry root biomass 37.1g/plant and N-uptake-325 mg/plant).

ii) Similarly, seedling inoculation of *Azospirillum lipoferum* -l gave superior performance in three grasses (*C. ciliaris, C. setigerus* and *D. annulatum*) in four cuts (*C. ciliaris* -total green forage yield-79.2g/plant, I-114.1g ; *C. setigerus* -C-55.4g/plant, I84.2g,*D. annulatum* -C-42.8g I-64.6g as compared to other two *A. lipoferum* strains (2 and ICM1001). Increased dry matter accumulation and crude protein content was also observed in these by this strain the highest CP content being in *C. setigerus* (7.5%). Greater improvement in the uptake of N and root biomass was also exhibited with strains-1 (Table-20).

iii) Similarly, field response of *C. ciliaris* to inoculation with seven different strains of *Azospirillum* species revealed greater green forage yields benefit (+33-35.8%) in four cuts on account of two *A. lipoferum* strains (strain 1 and 2) while five *A. brasilense* strains recorded only 18.5 to 25.2% increase in yield over uninoculated control. Dry matter accumulation and crude protein content in plants also followed the same trend. The greater gain in N (available N 195kg/ha) and the highest *Azospirillum* counts (10.5x10⁶ cells/g dry soil) was observed in the rhizosphere of A-I-1 inoculated treatment.
Comparative efficacy of Azospirillum and Azotobacter

In a pot culture experiment using red soil, the efficacy of two N$_2$-fixers (Azospirillum lipoferum ICM-1001 and Azotobacter chroococcum ICM-2001) was studied on seven grass species (C. ciliaris, C. setigerus, D. annulatum, P. antidotale, Pennisetum polystachyon, P. maximum and Bothriochola intermedia) under two methods of inoculation (seed and seedling). Forage yields were recorded in two cuttings. The results showed greater potential of these N$_2$ fixers in grasses for higher forage production (mean% increase 22.7-36.2) when applied through seedlings as compared to seed bacterization (mean % increase 13.2-22.9). Significantly highest green forage (35.8g/plant) and dry matter yields (12.2g/plant) as well as C P content (7%) in D. annulatum due to seedling inoculation with Azospirillum whereas maximum gain by Azotobacter was noticed in case of P. antidotale (green-17.4g/plant, D M-5.0, C P content-7.5%).

Pasture legumes

Pot culture studies using red and medium black soils were undertaken with a view to assess the need for rhizobial inoculation in pasture legumes. Nodulation, growth and forage yield as well as nitrogen content in plants of uninoculated ten species of stylosanthes (S. hamata, S. humilis, S. scabra, S. viscosa, S. hamata verano, S. fructicosa, S.sympodiae, S. capitata, S. subsericea, and S. guianensis) and five of Desmodium (D. intortum, D. dicolor, D. tortuosum, D. distortum, D. sandwicense) were recorded after 75th day of sowing.

The data indicated marked variability in natural nodulation, yield and N status in different legume species. In view of maximum nodulation (95/plant) in case of S. hamata and D. intortum (10/plant) in red soil, it may be inferred that it contains greater population of efficient native rhizobia for these legumes. The results suggest a need for Rhizobium inoculation in getting augmented forage yields.

Inoculation with specific strain of Rhizobium TAL 655 and A. chroococcum ICM 2001 in combination proved to be most effective in respect of nodulation (46/plant) and highest increase in green (+ 29.7%), and dry matter yields (+ 27.1%) crude
protein accumulation (+38.7%) as well as N-up-take (Rhizobium-90mg; R+AI-174mg/plant) by *Centrosema pubescens* over rhizobial inoculation alone.

2.2 Glimpses of Grazing in India

(R.K.Tyagi)

Studies on grazing resources and systems in Jammu & Kashmir

The total area available for grass production/grazing lands has been estimated to be nearly 1.1 m ha. This amounts to 46.42 per cent of the total reporting area of the state (2.41 m ha). The forest, permanent pastures, miscellaneous tree crops and groves, cultivable wasteland and fallowlands constituted 27.25%, 5.10%, 3.11%, 6.30% and 3.69% of the total reporting area respectively. A large proportion of grazing land is observed in the districts of Doda, Udhampur, Jammu, Rajouri, Kathua and Poonch.

Forest areas are the main component of the grazing lands. Doda (53.27%), Udhampur (44.49%), Rajouri (37.20%) and Kathua (27.46%) districts of Jammu Division have recorded a considerable proportion of forest areas.

The area under permanent pastures, miscellaneous tree crops and groves and cultivable wastelands is the second important grazing resource. The percentage under such lands ranges from 12.33% in Udhampur to 26.47% in Kargil district. Their high proportion is recorded in the districts of Kathua division.

The grazing is also practised in the fallow lands but their use is restricted as per the choice of the owner of such fields. Their percentage varies from 0.25 in Kargil to 9.71 in Pulwama district. It is recorded below 5% in most of the districts.

Sheep and goats are the major components of migratory livestock. Out of the total migratory livestock (1.46 m), in 1980-81 about 1.44 m were sheep and goats. Buffalo was the second important component. The number of cattle and other livestock was comparatively insignificant. The migratory livestock enumerated during 1982 was found smaller (10.47%) in comparison to previous years. The percentage of migratory component to total
livestock was recorded 28.8%, 16.2%, 14.7%, 0.97% and 0.09% for goats, sheep, other animals, buffaloes and cattle respectively.

2.4 Grassland and Fodder Atlas of Bundelkhand

(R.K.Tyagi)

The land use categories viz., forest, permanent pastures, miscellaneous tree crops and groves, cultivable wastelands and fallow lands have been earmarked as a resource for grazing which have combinedly been estimated in 1984-85 to be nearly 2.68 million ha and amount to 38.39 per cent of the total reporting area of the region i.e. 7.00 mha.

The districtwise grazing area in percentage varies from minimum 14.03 per cent in Jalaun to maximum 56.89 per cent in Panna district. The districts recording very high percentage (above 50%) are Panna, Damoh and Lalitpur while the remaining districts registered high percentage (25-50%) except Datia and Jalaun which have below 25 per cent. The data reveals that the outstanding concentration of grazing resources is found in the southern Bundelkhand which forms part of Vindhyan tableland and hill ranges.

The forest areas account for 17.8 per cent to the total area of the region. It covers 1246 thousand ha of land out of the total reporting area. They have significant proportions in the areas of Vindhyan hill ranges and table land which occupy major parts of Panna, Damoh and Sagar districts where the percentage of forest area has been recorded 38.00%, 36.00% and 28.00% respectively. This area also gets comparatively higher rainfall (1300 mm) which favours the growth of forests. The extent of forest area in Bundelkhand has shown increasing trend since it was recorded 9.44 per cent in 1970-71 and 12.16 per cent in 1976-77.

The areas under permanent pastures cover 367 thousand ha of land and account for 5.24 per cent of the total reporting area. They have, particularly, been marked in the districts of Sagar (12.00%), Chhatarpur (10.00%), Tikamgarh (13.00%) and Damoh (8.00%). It is found negligible in the northern part of the region covering Banda, Jalaun, Hamirpur and Jhansi where a larger proportion of land has become under cultivation due to fertile soil and better means of irrigation.

The land under miscellaneous tree crops and groves accounts for only 0.38 per cent and occupy 27 thousand ha of land. Some proportion of such areas is found in the northern part of the region, particularly, in the districts of Datia (3.00%) and Banda (1.00%). It is below 1.00% in other districts.

The cultivable wastelands cover 530 thousand ha of land and account for 7.57 per cent of the total reporting area. The outstanding concentration is found in the districts of Lalitpur (25.00%) and Chhatarpur (12.00%) where irrigation facilities are limited, rainfall is low and soils are infertile. The low percentage (around 1.00%) is recorded in Sagar and Jalaun districts. Such areas have shown decreasing trend while compared with the position of 1970-71 (20.05%) and 1976-77 (16.11%). This is mainly because of their conversion into cultivated area and allotment to landless persons as per Govt. directives.

The fallow lands occupy an area of 510 thousand ha which account for 7.28 per cent of the total reporting area. The high percentage of such lands is found in the districts of Banda (15.00%), Lalitpur (12.00%) and Chhatarpur (10.00%). Such areas are owned by the individual farmers but are generally utilized for grazing by others also. The fallow lands produce good quantity of grass during rainy season and some farmers harvest the grass as a crop.

SS-3: SOIL STUDIES ON AGROFORESTRY AND SILVIPASTORAL SYSTEMS OF FORAGE PRODUCTION

3.1 Studies on bacterial mediated N\textsubscript{2} fixation under agroforestry system of forage production

(M.R.Pahwa)

Response of Leucaena leucocephala to
microbial inoculation: Microbial cultures viz. *Rhizobium loti* strains (LL28-2, TAL-82 and TAL-582); VAM fungi (*Glomus fasciculatum*); phosphate solubilizing bacterium (*Bacillus polymyxa* H$_s$); phosphate solubilizing fungi (*Aspergillus awamoori*) and *Azotobacter chroococcum* ICM-2001 were tried singly and in combination on *L. leucocephala* var Silvi 4 under potted conditions using red soil. The results are as under:

i) Associative effects of *B. polymyxa* H$_s$, *A. awamoori*, *R. loti* LL-28-2, VAM fungi were found to be more pronounced in terms of nodulation (20/plant), green (47.5g/plant) and dry herbage yields (16.1g/plant) as well as nitrogen content (3.8%) than that of *Rhizobium* alone.

ii) Inoculant containing multi-strain of *Rhizobium* (TAL-82+TAL-582+LL-28-2) gave superior performance in terms of nodulation (22/plant), herbage yields and nitrogen content in plants.

iii) Inoculation of *Rhizobium* in presence of VAM fungi was found to produce higher nodulation (green yield-27.18 DM-10.8/plant), herbage yields and crude protein content (23%) as well as nitrogen uptake (397mg/plant) by plants.

iv) Nodulation, green and dry herbage yields as well as crude protein accumulation were significantly highest on inoculation with a mixture of specific *Rhizobium* and two strains (ICM-2001 and S-3) of *Azotobacter*. Such a favourable effect was also observed on nitrogen uptake (558.8 mg/plant) by the plants.

3.2 Micrometeorological studies in multi-canopy cropping situation

(Pradeep Behari and P.S.Pathak)

The field experiment was continued under Agroforestry system with oat crop as understory component in place of guinea grass. Three agrosystems viz open canopy with pure oats, under leucaena canopy (2 tier) and the third one with populus, leucaena and oats (3 tier) were involved in the study.

The amount of incoming radiation to the oats surface varied with the cropping systems. The highest amount of average radiation come to open canopy of oats surface (720 μE/m²/s) followed by 98% (704 μE/m²/s) and 74% (530μE/m²/s) of open radiation under 2 tier and 3 tier systems respectively. The relative humidity was found to be on the reversed order of the incoming radiation i.e. highest RH with 3 tier system followed by 2 tier and open canopy situation. On an average lowest leaf temperature of oats was recorded under 3 tier situation and highest ambient air temperature was found to be in open canopy situation. The average soil temperature in 2 tier system is higher than other systems.

Under established agroforestry system guinea grass was again taken as understorey crop in place of oats for the 2nd year. There agrosystems viz open canopy with pure guinea, leucaena with guinea (2 tier) and populus, leucaena and guinea (3 tier) were involved in the study.

In all the three seasons of crop growth period (summer, rainy and autumn), the incoming radiation to the guinea grass surface and soil temperature varied with the cropping system i.e. the highest in open canopy situation, followed by 2 tier and lowest in 3 tier situation. The relative humidity was found highest in 2-tier system followed by 3-tier and least in open canopy situation. On the other side leaf temperature and ambient temperature were found highest in open canopy followed by 3-tier and least in 2-tier situation. The higher value of relative humidity and lower values of leaf and ambient temperature in 2-tier system is due to dense foliage of leucaena hedge. The micro meteorological information under different canopy situation at guinea grass surface is presented in table-21.
4.1 Relative performance of some range grasses under sodic conditions

(Dashrath Singh and R.B.Yadav)

A pot culture experiment was conducted during kharif 1988 to study the sodicity tolerance of five range grasses viz., *Cenchrus ciliaris*, *Dichanthium annulatum*, *Chrysopogon fulvus*, *Sehima nervosum* and *Bothriochloa intermedia*. Five sodicity levels (control, 20ESP, 40ESP, 60ESP and 80ESP) were created artificially by adding sodium carbonate into the soil. The corresponding pH values of these levels were 7.6, 9.0, 9.5, 9.8 and 10.0 respectively. It was observed that except *Chrysopogon fulvus*, none of the grasses could germinate beyond pH 9.5. *Chrysopogon fulvus* germinated upto pH 9.8. However, the seedlings died after some time at pH 9.8. The growth of all grasses were adversely affected by increasing sodicity levels. Maximum reduction in the growth, measured in terms of green forage yield, was recorded with *Sehima nervosum* (79.8%) indicating its least tolerance to soil sodicity. The lowest reduction in green forage yield was observed in case of *Chrysopogon fulvus* (52.6%) which indicated that *Chrysopogon fulvus* was most tolerant to soil sodicity. The order of sodicity tolerance of these grasses was *Chrysopogon fulvus* > *Dichanthium annulatum* > *Bothriochloa intermedia* > *Cenchrus ciliaris* > *Sehima nervosum*.

Soil fertility evaluation and mapping of C.R.Farm

(R.B.Yadav and R.K.Tyagi)

A field/laboratory study was conducted to evaluate the fertility status of the Central Research Farm of the Institute. Soil samples from two different depths (0-15 and 15-30 cm) were collected from all the blocks/fields and were analysed for different physico-chemical parameters. The summary of the data is presented in Table-22.

It was observed that most of the soils of the farm were sandy clay loam to clay in texture and low to medium in different nutrients. As evident from table-22, all the soils were low in available nitrogen which ranged from 48.6 kg/ha to 269.7 kg/ha. The available phosphorus content of the soils
varied from 2.24 kg P/ha to 81.76 kg P/ha. Majority of the soil samples (65%) were low in available phosphorus. About 26 percent samples were medium and only 9 percent high in available phosphorus. The available potassium content of the soils showed a large variation. It ranged from 67.5 kg K₂O/ha to 1378.9 kg K₂O/ha. About 50 percent of the samples were medium in available potassium. Rest of the 50 percent samples were almost equally distributed under low and high rating classes. The organic carbon content of the soils ranged from 0.12 percent to 0.84 percent. Most of the soils were low to medium in organic carbon. Only few samples (6.7%) were high in organic carbon.

From the above results, it may be concluded that most of the soils of the farm are low in fertility and require judicious use of FYM and nitrogenous and phosphatic fertilizers. It is also evident from this study that there is a need to pay attention towards the use of potassic fertilizers as some of the fields have already been exhausted in potassium.

Table 22: Soil nutrient content and per cent distribution under different ratings

| Nutrients        | Range             | Rating  |  |  |
|------------------|-------------------|---------|  |  |
|                  |                   | Low     | Medium | High |
| Nitrogen         | 48.6-269.7 kg/ha  | 100     | -      | -    |
| Phosphorus       | 2.24-81.76 kg P/ha| 67.6    | 26.2   | 9.2  |
| Potassium        | 67.5-1378.9 kg K₂O/ha | 29.2   | 48.8   | 22.0 |
| Organic Carbon   | 0.12-0.84%        | 56.7    | 36.6   | 6.7  |
DIVISION OF PLANT ANIMAL RELATIONSHIP

PAR-I: NUTRIENT LEVELS AND ANTI QUALITY FACTORS

1.1 Quality of forages as influenced by gene environmental interaction

(L.K.Kamani)

1. Studies on the quality parameters of Lablab purpureus

Twenty varieties of Lablab purpureus bred at this Institute were analysed for dry matter, crude protein, NDF, ADF, hemicellulose, cellulose, lignin, plant silica, total ash, acid-insoluble ash and in vitro true dry matter digestibility (IVTDMD).

The percentage variation for dry matter (25.40 to 35.45), crude protein (14.31 to 24.62), NDF (37.64 to 50.10), ADF (27.67 to 40.88), hemicellulose (6.60 to 16.35), cellulose (22.82 to 31.33), lignin (4.33 to 10.66), plant silica (0.24 to 0.90), total ash (5.72 to 10.00), acid-insoluble ash (1.68 to 4.00) and IVTDMD (66.90 to 75.45) were observed.

Variety R1/2214-II proved better having the maximum crude protein (24.62%) and minimum NDF (37.64%), ADF (27.67%), lignin (4.33%), cellulose (22.82%) and maximum IVTDMD (71.37%). Maximum IVTDMD in R1-7/27 was observed as 75.45 per cent. The dry matter, however, was much lower (by 6 percentage units) than the variety R1/36 which gave maximum (35.45%) dry matter percentage. Variety R1/2218, on the other hand, was found to be the poorest among all the varieties studied, as it was having the minimum (14.31%) crude protein and maximum lignin (10.66%), total ash (10.00%) and almost maximum NDF and ADF (49.34 and 37.09% respectively) maximum being 50.10% in R1-10/13 and 40.88% in R1/34, respectively.

2. Effect of gene environment on the quality of Pennisetum pedicellatum and cowpea

Samples of 9 varieties of Pennisetum pedicellatum in the prerelease stage collected from Jhansi, Ranchi, Palampur and Hyderabad centres of All India Coordinated Research Project on Forage Crops were analysed for quality traits. The results showed that the varieties under study performed better (having CP from 5.4 to 6.8%) in the subtropical climate of Jhansi having a temperature variation from 14° to 38° C and the rainfall of 554 mm during the crop period. The cell-wall was observed to be lower (from 60.0 to 67.5% as compared to 66.5 to 74.0 %) when the crop was grown in the humid temperate region having a temperature variation from 12° to 22° C. This indicated that the cell-wall content had a correlation with the temperature.

1.2 Chemical constituents and nutritional quality of forages

(S.C.Gupta)

1. Studies on quality and anti-quality traits in hybrid napier as influenced by seasons and varieties

Samples from five cuts, after uniformly harvesting the crop on 10.3.1987, were collected from three ICFRI varieties (Nos. 2, 3 and 6), along with NB-21 (as control), for detailed studies on their nutritional quality and antinutritional factors. The harvesting dates were: 28/4/1987, 23/6/1987, 28/7/1987, 11/9/1987 and 28/10/1987.

The results showed that:

(i) Nutritional quality was more influenced by
cuts pertaining to regrowths in different seasons than varieties.

(ii) More nutritious forage, i.e. containing high CP (9.9%), SC (19.1%), ASA (8.0%) and minerals, and low NDF (60.8%), ADF (37.7%) and C+HC (47.8%), was harvested in first cut. It was followed by the regrowth of third cut. The CP content was low (7.2%). The other results were: 15.8, 9.6, 65.0, 41.4 and 55.9% respectively.

(iii) Among varieties, IGFRI No. 2 contained maximum desirable nutrients and lowest total fibre and some of its fractions. IGFRI No. 3 could be rated as the second best. The respective values of CP, ASA, DMD, DM, NDF, ADF and C+HC were; 10.0 and 8.3, 8.9 and 7.5, 56.7 and 55.6, 18.6 and 18.7, 63.2 and 65.5, 41.5 and 42.4, and 52.3 and 54.1%.

(iv) Nitrate was present in traces. Thus there was no toxicity problem to animals. The results were useful in studying differential accumulation of minimal amounts of nitrate under various situations.

(v) The oxalate content in first (TO=3.8%, SO=2.8%) and third (TO=4.0, SO =2.7%) cuts was higher than the lowest values (TO = 3.4%, SO = 2.2%) recorded in second cut. It showed that forage possessing higher nutritive attributes was likely to be accompanied by higher oxalate contents. A similar trend was also evident in results among different varieties. The oxalate content in IGFRI No. 2 (TO=4.0%, SO-3.1%) and IGFRI No.3 (TO-3.8%, SO=2.5%) was higher than the lowest values noted in IGFRI No.6 (TO = 3.4%) and NB-21 (2.2%).

Additional feed calcium counteracts the toxic effects of oxalate on calcium metabolism in animals. The calcium content in the forage was higher than what was expected to be normally present or recommended for meeting the nutritional needs of actively fattening (finishing) cattle. The calcium content in the present study ranged from 0.65 to 1.29%; mean = 0.88%. The range values reported for hybrid napier is 0.3 to 0.6%; mean = 0.4 and the recommended level in the rations of finishing cattle is 0.22 to 0.35% Ca.

1.3 (a) Ensilage of herbage and crop residues

(A.P. Singh and A. Rekib)

1. Biochemical changes in ammoniated silage prepared from freshly harvested forages

Following forage species were selected for silage making after ammoniation (generated from urea)

i) Sorghum stovers (DM 4%) - S
ii) Pennisetum pedicellatum (regrowth, full flowering, DM 26% - P
iii) Themeda mature (DM 54.3%)- T

These plants were chopped immediately after harvesting and ensiled in laboratory glass silos with 0, 2 and 4% urea (on dry matter basis).

Organoleptic tests: Silage prepared from above forage with and without ammoniation were of good quality. Due to biochemical changes of different silages, sorghum silage with 2% ammoniation gave the best silage. 0 and 4% urea treated sorghum silages could be classified as of good quality.

Untreated Pennisetum pedicellatum and Themeda fodders gave excellent silage with pH values of 4.1 and 4.3, NH$_3$ - N(%) 0.17 and 0.05, lactic acid 3.30 and 3.41, acetic acid 2.15 and 2.11 and flieg index 71 and 72, respectively. On the basis of flieg index and other biochemical changes, urea treated silages of P and T could be classed as "medium". Concentration of acetic acid was more in urea treated P and T silages than untreated ones.

Changes in the structural carbohydrates due to silage making and ammoniation revealed that:
(i) Ensiling of sorghum *kadbi* with or without urea had no effect on ADF, cellulose and lignine content, but there was significant rise in hemicellulose (25.9 vs 36.0%) and NDF (66.6 vs 77.5%). The percentage of hemicellulose and NDF amongst silage reduced due to urea treatment (HC 39.6 to 32.9 and NDF 80.4 to 74.4).

(ii) In *P. pedicellatum* silage, there was slight fall in lignine, cellulose and ADF content due to urea addition.

(iii) In *Themeda*, there was rise in hemicellulose, NDF and lignine content due to ensiling but the levels of urea addition had no effect on structural carbohydrates.

(iv) It was interesting to note that there was difference in the magnitude of change in structural carbohydrates due to silage making and urea addition in different species of forage crops.

2. Nutritional value of dry grass affected by ammoniation through urea or urea addition just before feeding

Dry chopped grass was treated with 40% water and 2% or 4% urea for ammoniation (T1 and T2). After 30 days of ammoniation these were opened for chemical and feed quality evaluation. Ammoniated grass was offered to the animals one day after aeration. Similarly, urea was mixed daily with chopped dry grass at the rate to have crude protein content equivalent to 2% and 4% ammoniated grass (T3 and T4) and fed to other groups of animals. There were four groups of 3 adult crossbred bullocks each. A digestion trial was conducted. Animals were supplied ad libitum roughage with 15 g common salt, 15 g mineral mixture and 0.5 g vitablend to each animal daily.

Crude protein content of T1 and T2 groups were about 8.5% while that of T3 and T4 groups, it was 11.2%. Cell wall constituents of the grass as affected by ammoniation and urea treatment was also estimated. It was found that NDF, ADF and hemicellulose increased due to urea treatment but by ammoniation there was slight fall in the NDF and hemicellulose values. 2 and 4% ammoniated grass had 0.29 and 0.39% NH3-N, 0.58 and 0.86% water soluble N, 8.52 and 11.21% crude protein and 1.58 and 1.42% acetic acid, respectively, after one day aeration.

It was observed that virtually there was no difference between different treatments as far as dry matter intake was concerned.

There was little variation in the digestibility coefficients of various nutrients except hemicellulose where it was high with ammoniation (91.4%) than urea addition (71.8%). Higher application of urea (T4) had given higher digestibility of hemicellulose (96.9% vs 86.0%). DCP content was 4.1, 3.9, 4.5 and 6.3% in T1, T2, T3 and T4 respectively. While there was no variation in TDN values (44.9 to 50.0%). Blood urea levels were 20.2, 40.8; 20.8 and 50.4 mg/100 ml of blood in T1, T2, T3 and T4 respectively. This showed that urea treated material raised the blood urea level considerably.

3. Silage quality and nutritive value of *Cenchrus ciliaris* ensiled with urea (1%) or with *Stylosanthes hamata* (1:1)

*Cenchrus ciliaris* (at the initiation of flowering) was ensiled either with *Stylosanthes hamata* (1:1) or with 1% urea (fresh weight basis). Similar amount of cenchrus and stylo was converted to hay. Cenchrus hay was also prepared separately.

Feeding trial on (1) *Cenchrus ciliaris*+*Stylosanthes hamata* silage (2) *Cenchrus ciliaris* + *Stylosanthes hamata* hay (3) Cenchrus + 1% urea (fresh weight basis) silage (4) Cenchrus + urea at the time of feeding was conducted on 12 adult crossbred bullocks (3 animals in each treatment).

1.3 Evaluation of different species/varieties
of forages as silage

(A.B. Majumdar)

1. Evaluation of sorghum var. PC-6 silage for its quality

Sorghum var. PC-6 at flowering stage was ensiled after 24 hrs wilting. The silos were opened after 60 days of ensiling. Physical appearance of silage was excellent. It had pleasant aroma and was found in good texture. Biochemical analysis of silage revealed that no undesirable type of fermentation occurred as seen by low ammonia N (0.041%) and negligible amount of butyric acid, (0.02%). A lactic acid type fermentation took place as observed by appreciable amount of lactic acid (6.58%). Production of lactic acid together with low ammonia (5.54 as % NH₃-N of total N) seemed to be responsible for maintaining low pH (4.87) which is essential for maintaining desirable type of fermentation and thereby producing good quality silage. L % T value (58.64) shows that silage was stable. Volatile acid production was low (Acetic acid 4.62%, Butyric acid 0.02%). Overall quality of the silage is graded good as seen by flieg-index value (70).

PAR-2: NUTRITIONAL EVALUATION OF FORAGES AND FORAGE PRODUCTION SYSTEMS

2.1: Investigations on the role of chemical attributes of forages on the intake as well as digestibility coefficients of various nutrients

(V.C. Pachauri)

1. Milk production potential of berseem in crossbred cattle

12 cows were divided into two groups of 6 each on the basis of average milk yield (9.8 litres and 9.7 litres per head per day). The average live weight in the two groups was 304 kg and 334 kg. Group one served as control and the nutrient requirements of the cows were met through concentrate mixture, limited berseem and dry grass ad lib. Group two was offered 30 kg berseem, 50% of concentrate mixture of control group and ad lib dry grass. The experiment continued for 3 months. Digestibility trial was conducted after 1.5 months feeding. The body weight of individual cow was recorded every fortnight and daily milk yield record was maintained. After 3 months period the cows of group one lost body weight @ 2 kg while in group two the loss was 7 kg. There was decrease in milk yield @ 1.02 and 0.13 litres in the respective groups. The intake of nutrients was fairly high in the two groups as per requirement. The digestibility coefficients were higher in group two. It may be inferred from the experiment that milk yield of 9.7 litres could be maintained on a feeding schedule of 30 kg berseem and 3 kg concentrate mixture and there was no adverse effect compared to control. The rations in group one and two furnished 10.67 and 11.57% DCP and 59.90 and 64.45% TDN (Table 23).

2. Milk production potential of sorghum fodder in crossbred cows

8 cows were divided into two groups of 4 each on the basis of milk yield (6.47 and 6.51 litres per day per head). The average live weight in the two groups was 306.4 and 304.4 kg. Group one served as control and the nutrients requirement were met through concentrate mixture and dry grass ad lib. Group two was offered sorghum fodder ad lib and 50% of concentrate mixture of control group. The experiment continued for two months. The digestibility trial was conducted at the end. The body weight of individual cow was recorded every fortnight and daily milk yield record was maintained. After two months there was a gain in body weight of 15.9 and 23.6 kg in group one and two respectively while milk yield in one and two groups was 4.59 and 4.27 litres. The decrease in both groups was due to advancement of lactation stage. The intake of nutrients was fairly high in the two groups
to meet the requirements. The digestibility coefficients of DM, CP, CF, CC and OM were higher in group one. DCP and TDN of the mixed feed were also higher in group one than group two (Table 24). This suggests that the experimental ration was inferior to the control although almost similar milk yield could be obtained in both groups.

3. Milk production potential of sorghum silage in cross bred cows

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

8 cows were divided into two groups of 4 each on the basis of average milk yield (7.3 and 7.5 litres respectively). The average live weight in the two groups was 351 and 358 kg respectively. Group one served as control and the nutrients requirement were met through concentrate mixture and dry grass ad lib. Group two was offered ad lib sorghum silage and about 50% of concentrate of control. The experiment continued for two months. The digestibility trial was conducted at the end. The body weight of the animals was recorded every fortnight and daily milk yield record was maintained. After two month period there was loss of body weight of 14 and 16 kg in the two groups respectively, while milk yield in the two groups was 5.2 and 5.7 litres respectively. The intake of DM in the two groups was 2.63 and 2.25 kg per 100 kg b.w. respectively but DCP intake in group two was less (73%) and this was also reflected in low CP digestibility in group two (57.00%) compared to control (79.95%). The digestibility coefficients of other nutrients were similar. DCP and TDN per cent of ration in the two groups were 9.50, 5.48 and 59.29, 56.60% respectively (Table 25). The study suggests that sorghum silage could not replace concentrate to meet 50% of crude protein requirements of the experimental cows.

2.3 Evaluation of protein quality of forages

(K.S. Ramachandra and P. Kumar)

1. Evaluation of protein

Berseem hay protected with formaldehyde (1%) was evaluated using growing goat kids with untreated berseem hay as control. The experimental animals were given crushed oats @ 0.4 kg/animal/day. The average dry matter intake was 0.72 and 0.70 kg/head/day respectively in the control and treated groups. The dry matter digestibility was 76.04 and 74.75%. It was observed that formalin treatment depressed the voluntary intake of dry matter and crude protein but there was a significant increase in the digestibility percentage of crude protein and ether extract in the treated group (CP 81.69 vs 77.44%, EE 76.99 vs 65.17%). Due to improved utilization of both DCP and TDN, the kids in the treated group recorded a body weight gain of 43.3 in comparison to 32.9 g/h/day in the control group.

2.9: Micronutrients in pasture and forage crops and their utilization

(K.S. Ramachandra)

1. Trace mineral availability to milch animals under different forage based feeding systems

Two systems of forage based diets were evaluated in milch animals.

1) Berseem (10 kg) + Dry grass + Concentrates (4.5 kg) Group-I

Berseem (30 kg) + Dry grass + Concentrate (2.7 kg) Group-II

2) Sorghum silage + Concentrate (50% of control) Group-I

Dry grass + Concentrate (full quota) Group-II.

The availability of some of the important trace minerals like zinc, copper and iron through these feeding systems were determined. In the berseem based system, the average levels of intake of zinc was 201.07 and 185.42 ug/head/day in Group I and II respectively. The percentage retention was 38.07
### Table 23: Digestibility coefficient (%) of nutrients

<table>
<thead>
<tr>
<th>Group</th>
<th>Initial L.W. (Kg)</th>
<th>Final L.W. (Kg)</th>
<th>DM intake (Kg/LW)</th>
<th>DM</th>
<th>CF</th>
<th>CP</th>
<th>NFE</th>
<th>NDF</th>
<th>ADF</th>
<th>CC</th>
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<tr>
<td>I</td>
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<td>302</td>
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<td>65.46</td>
<td>66.35</td>
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<tr>
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<td>334</td>
<td>327</td>
<td>4.34</td>
<td>70.45</td>
<td>69.25</td>
<td>79.09</td>
<td>72.25</td>
<td>65.94</td>
<td>69.29</td>
<td>76.52</td>
<td>72.22</td>
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</table>

### Table 24: Digestibility coefficient (%) of nutrients.

<table>
<thead>
<tr>
<th>Group</th>
<th>Initial L.W. (Kg)</th>
<th>Final L.W. (Kg)</th>
<th>DM intake (Kg/LW)</th>
<th>DM</th>
<th>CF</th>
<th>CP</th>
<th>NFE</th>
<th>NDF</th>
<th>ADF</th>
<th>CC</th>
<th>OM</th>
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<tr>
<td>I</td>
<td>306.4</td>
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<td>79.49</td>
<td>68.72</td>
<td>52.22</td>
<td>63.37</td>
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<tr>
<td>II</td>
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<td>2.84</td>
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<td>53.78</td>
<td>58.40</td>
<td>62.56</td>
<td>56.67</td>
<td>44.15</td>
<td>61.30</td>
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</table>

### Table 25: Digestibility coefficient (%) of nutrients.

<table>
<thead>
<tr>
<th>Group</th>
<th>Initial L.W. (Kg)</th>
<th>Final L.W. (Kg)</th>
<th>DM intake (Kg/LW)</th>
<th>DM</th>
<th>CF</th>
<th>CP</th>
<th>NFE</th>
<th>NDF</th>
<th>ADF</th>
<th>CC</th>
<th>OM</th>
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<tbody>
<tr>
<td>I</td>
<td>351</td>
<td>337</td>
<td>2.63</td>
<td>62.40</td>
<td>57.21</td>
<td>74.95</td>
<td>68.06</td>
<td>62.40</td>
<td>62.47</td>
<td>62.30</td>
<td>63.94</td>
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<tr>
<td>II</td>
<td>358</td>
<td>342</td>
<td>2.25</td>
<td>61.10</td>
<td>57.49</td>
<td>57.00</td>
<td>67.46</td>
<td>67.37</td>
<td>61.38</td>
<td>59.46</td>
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</table>
and 31.76%. It was observed that increasing the levels of berseem with consequent reduction in concentrate feeding, there was no considerable decrease in the zinc availability. Similar trend was observed in case of copper and iron also. It was evident that this feeding system contained the minerals sufficient to cover the prescribed NRC requirements for these minerals (Cu-10 ppm, Zn-40 ppm, Fe-ppm).

2.5 Studies on the nutritional status of *Cenchrus ciliaris* grass and *Stylosanthes* legume in relation to animal performance

(N.C. Verma)

1. By mixing *Stylosanthes* hay with that of *Cenchrus* hay, crude protein and calcium got significantly enhanced. It reduced the NDF, ADF, total ash and silica and did not substantially alter the phosphorous, cellulose and lignin levels. Consumption of dry matter and digestible energy did not differ significantly but the intake of DCP increased significantly.

2. Digestibility coefficients of different nutrients, except ether extract, also improved significantly with the incorporation of the legume *S. hamata* hay with *C. ciliaris* grass.

3. Growth rates of lambs showed significant improvement when the legume component constituted 75 per cent in the ration compared to the *C. ciliaris* group. Energy consumption, however, reflected non significant differences in the performance of the first three groups receiving 0, 25 and 50 per cent *Stylosanthes* hay in the diet.

4. The feed efficiency expressed in terms of weight gain per kg DM and per Mcal DE intake did not indicate significant difference amongst the treatments but weight gain expressed per unit digestible protein intake showed significant decrease with the increased level of stylo in the diet.

This study indicated that *C. ciliaris* grass alone does not satisfactorily support growth of lambs. The nutritive value of the pasture can be materially improved by the incorporation of *S. hamata*.
DIVISION OF SEED TECHNOLOGY

SPR-2: STUDIES ON CROP GEOMETRY, FERTILIZER USE AND MOISTURE STRESS IN RELATION TO SEED PRODUCTION IN FORAGE CROPS

2.1 Fertilizer use, planting geometry and dates of sowing studies in turnip and cowpea for seed production

(P.S. Tomer, S.N. Singh, V.J. Shivankar and S.M. Mishra)

Effect of planting geometry and nitrogen levels on seed yield of forage turnip

An experiment comprising of 3 spacings (50 x 30, 50 x 40, 50 x 50 cm) and 4 levels of nitrogen (0, 40, 80 and 120 kg N/ha) was conducted. Turnip planted at spacing of either 50 x 30 or 50 x 40 cm produced 27.3 to 34.0% higher yield over wider spacing of 50 x 50 cm. Further it was observed that 80 kg and 120 kg N/ha, which did not differ from each other with regard to yield, increased seed production markedly over control. The increases due to 80 kg N/ha were 30.7 and 7.7% over control and 40 kg N/ha respectively.

Effect of dates of sowing and levels of nitrogen and phosphorus on seed production of forage turnip

An experiment comprising of 2 dates of sowing (first week of Dec. and first week of Jan.), 4 levels of nitrogen (0, 40, 80 and 120 kg N/ha) and 3 levels of phosphorus (0, 40 and 80 kg P₂O₅/ha) was conducted. Variety NP-3 proved to be the highest seed producer. The seed production efficiency of IFC 8401 was more or less equal to IFC 8402. Application of phosphorus was beneficial to the crop as seed yield increased by 111.2% with 40 kg P₂O₅/ha over no phosphorus application. Dose higher than 40 kg proved ineffective as there was no further improvement in seed yield. Application of potassium was not beneficial to any variety at any phosphorus levels.

Seed production efficiency of promising varieties of cowpea in relation to phosphorus and potassium levels

An experiment comprising of 3 varieties (IFC 8401, IFC 8402 and NP-3), 3 phosphorus levels (0, 40 and 80 kg P₂O₅/ha) and 2 levels of potassium (0 and 40 kg K₂O/ha) was conducted. July sown crop performed better than August sown. Application of 40 kg P₂O₅/ha improved the seed yield by 20.4% but application beyond 40 kg could not bring additional improvement. Application of potassium was not beneficial to either early or late sown cowpea.
Effect of foliage applied plant nutrients on seed yield and quality of siratro

The last year experiment was repeated to evaluate the influence of nutrients (\(\text{KNO}_3\), \(\text{P}_2\text{O}_5\), \(\text{ZnSO}_4\), \(\text{CuSO}_4\) and Borax each at 2 kg/ha) applied singly and in combination through foliage on siratro (Macropelium autropurpureum). Results revealed that foliar feeding of \(\text{CuSO}_4\) or \(\text{KNO}_3\) proved better than Borax and \(\text{P}_2\text{O}_5\). The increase was more than 13 and 17 kg per hectare over Borax and \(\text{P}_2\text{O}_5\), respectively. The yield was further improved when \(\text{KNO}_3\) and \(\text{CuSO}_4\) were applied in combination. The improvement was more than 24 kg over the single application of \(\text{CuSO}_4\) or \(\text{KNO}_3\).

Effect of levels of nitrogen, phosphorus and potassium on seed yield and quality traits of Clitoria ternatea

An experiment comprising 3 levels of nitrogen (0, 20 & 40 kg N/ha), 3 levels of phosphorus (0, 30, 60 kg P\(_2\text{O}_5\)/ha) and 2 levels of potassium (0 & 30 kg K\(_2\text{O}\)/ha) was conducted to maximize seed yield and seed quality traits of Clitoria ternatea.

Clitoria ternatea did not respond to nitrogen application. On the other hand it responded to phosphorus application. 60 kg P\(_2\text{O}_5\)/ha increased seed yield markedly over 0 and 30 kg P\(_2\text{O}_5\)/ha. Potassium application proved beneficial as 30 kg K\(_2\text{O}\)/ha increased seed yield over 0 kg K\(_2\text{O}\)/ha.

2.3 Agronomical studies for exploiting system based seed production potential in forage

(R.K. Pandey)

Evaluation of seed cowpea based fodder-seed production systems

Experiment was repeated this year also. Three crop combination systems were evaluated in which a major crop of seed cowpea (Vigna unguiculata) cv NP-3 was sown in 50 cm apart rows and intercropped with the fodder crops of cowpea HFC42-1, guar (Cyanopsis tetragonoloba) cv. IGFRI-212 and urad (Vigna mungo), individually. Fodder crops were grown in the inter-row space @ one line between two rows of seed cowpea. In addition, two more cropping systems of cowpea cv NP-3 were included. In both of these treatments, cowpea cv NP-3 was sown in 25 cm row spacing. In case of one, the alternate rows and in the other, each fourth row, alternatively were harvested for fodder and leftover rows of both these systems were maintained for seed production. For comparison, four treatments of seed cowpea cv NP-3 were also added. In these four, two were of broadcast sowing @ 20 and 40 kg/ha seed rate and remaining two were of line sowing at 25 cm row spacing (40 kg/ha seed rate) and 50 cm row spacing (20 kg/ha seed rate). In case of all the three above fodder crops 20 kg/ha seed rate was used. Fodder rows under each cropping system were harvested after 40 days of sowing. Fodder oat (Avena sativa cv Kent) was raised during winter to assess the residual effect. In seed yield the fodder-seed production systems viz. 25 cm apart row crop of cowpea cv NP-3 with a fodder harvest of alternate rows (7.4 q/ha) as well as 50 cm apart row crop of seed cowpea cv NP3 with a fodder harvest of alternate rows (7.4 q/ha) or urad (8.6 q/ha) were at par to 50 cm apart row crop of seed cowpea (8.8 q/ha). There was no significant difference between the seed yield of seed cowpea cv NP-3 sown at different row spacings of 25 and 50 cm. Similarly, the seed yields recorded under the broadcast sowing at variable seed rates of 20 and 40 kg/ha were marked to be at par. However, the 50 cm apart row crop of seed cowpea cv NP-3 outyielded both the treatments of broadcast sowing (20 and 40 kg/ha seed rate).

As regards the contribution of leguminous fodder, the crop combination system where 50 cm
row crop of seed cowpea cv NP-3 intercropped with a alternate row crop of fodder cowpea cv HFC 42-1 recorded the maximum drymatter yield of 13.2 q/ha and was found to be significantly superior over rest of the treatments. This fodder-seed production system was, thus, marked to be more promising as this provided highest additional yield of leguminous fodder (dry matter) having 19.6 percent crude protein (on dry matter basis) and did not significantly reduce the seed yield of seed cowpea cv NP-3 in comparison to seed cowpea cv NP-3 at 50cm row spacing.

In last year trial, the 50cm apart row crop of seed cowpea cv NP-3 intercropped with alternate row crop of fodder cowpea cv HFC 42-1 did not reduce drymatter yield of fodder in subsequent oat crop (69.8 q/ha).

Based on two years results the fodder-seed production system of 50cm apart row crop of seed cowpea cv NP-3 intercropped with a alternate row crop of fodder cowpea cv HFC 42-1 provided highest additional drymatter yield of leguminous fodder without reducing the seed yield as compared to monoculture of seed cowpea cv NP-3 at 50cm row spacing.

2.4 Agronomic investigations for increasing seed yield in grasses

(G.K.Dwivedi)

Nitrogen economy by legumes association in Panicum maximum for seed production

The experiment comprising of 10 treatments of both intercrops (Desmanthus virgatus, Sesbania aegyptiaca, Macroptelium atropurpureum, Desmodium tortuosum and Stylosanthes hamata) and nitrogen levels in Panicum maximum (0, 10, 20, 30 and 40 kg N/ha) was conducted. The association of siratro (Macroptelium atropurpureum) proved to be best in enhancing seed yield of Panicum maximum, the effect of which was equivalent to 40 kg N/ha.

Studies on different foliage applied plant nutrients for seed production in Setaria sphacelata

The experiment was repeated during the second year to evaluate the significance of foliar nutrients (KNO₃, Urea, SSP, MgSO₄ and ZnSO₄) applied singly and in combination with Setaria sphacelata cv Nandi for seed production. Results showed that KNO₃ applied as foliage (42.5 kg/ha) was found to be significantly better than urea (39.8 kg), ZnSO₄ (37.9 kg), MgSO₄ (32.8 kg) and SSP (31.5 kg)/ha. However, effectiveness of KNO₃ was further enhanced when it was sprayed with urea.

2.5 Seed yield of sorghum and lucerne in relation to supply of boron

(S.M.Misra, S.N.Tripathi and P.S.Tomer)

Boron nutrition of sorghum in relation to nitrogen supply

A study comprising of 4 levels of nitrogen (0, 30, 60 and 90 kg N/ha) and 4 levels of boron (0, 0.5, 1.0 and 1.5 kg B/ha) was undertaken. It was observed that boron application (0.5 to 1.5 kg B/ha) did not show any improvement in seed yield of sorghum when it was applied without nitrogen. However, when boron was applied along with nitrogen, seed yield was increased markedly.

Boron in relation to calcium in seed lucerne

An experiment comprising of 2 levels of boron (0 and 900 g B/ha) and 6 levels of calcium (0,180,360,540, 720 and 900 g Ca/ha) was conducted. These nutrients were sprayed in three splits at an interval of 15 days during anthesis period of lucerne. It was observed that application of Ca did not increase the seed yield of lucerne. However, boron application increased the yield. The effectiveness of boron was further enhanced when B was applied along with either 360 or 540 g Ca/ha.
3.1 Seed borne diseases and their control in forage crops

(S.N. Singh)

Studies on control of seed borne diseases especially Fusarium spp. and Macrophomina phaseolina spp. in cowpea

Thiram, Dithane M-45 and Bavistin @ 2.5 g/kg seed as alone and their combinations both as dry seed treatment, as well as one spray 0.25% was tried with variety NP-3. These fungicides increased the emergence and reduced the pre-and post-emergence seedling mortality by 7.8 -14.3% and in comparison to untreated seeds. Bavistin + Dithane M-45 was found as best for the control of root rot caused by Macrophomina phaseolina and increased the seed yield up to 52% over the untreated control. The percentage infection appears to correlate with yield per plant in the fungicide treated plants.

Evaluation of fungicide against head mould (Fusarium spp. and Curvularia spp.) and other leaf spot diseases in sorghum

Amongst different treatments of fungicides, Dithane M-45 + Bavistin (@ 2.5 g/kg seed) resulted in better germination, emergence, low mortality and higher yield over untreated seeds of jowar variety HC-136. However, fungicides tested singly did not reduce the seedling mortality, grain mould and foliage diseases simultaneously. In case when Dithane M-45 + Bavistin was seed dressed and subsequently sprayed along with Endosulfan (0.075%) at boot stage kept the seed free from grain moulds and leaf folder as compared to seed dressing with Dithane M-45 + Bavistin only.

Studies on control of seed borne diseases especially Fusarium rot in berseem

An experiment comprising of dry and wet seed treatment with Dithane M-45, Thiram and Bavistin as alone and their combination @ 3 g per kg seed with IGFRI Wardan variety was conducted. Bavistin + Thiram was found much effective in checking the seedling mortality due to Fusarium oxysporum up to a great extent with vigorous seedlings producing higher seed yield by 62-81% over untreated seeds.

Isolation and identification of different microorganisms associated with seeds of forage crops

In vitro experiment was conducted after harvesting of sorghum cultivar HC-136 by germinating the seeds of different fungicidal treatments by "Between paper" method (ISTA 1976).

The percentage of fungi associated with infected discoloured seeds were as follows: Fusarium moniliforme 18%, Curvularia lunata 15%, Fusarium semitectum 11%, Alternaria alternata 8%, Helminthosporium tetramera 6% and Phoma sorghina 4%. There was a great reduction in the percent incidence of these pathogens in seed plots which were sprayed with Bavistin+Dithane M-145 followed by Bavistin and Thiram.

By the germination studies it can be concluded that sorghum seeds respond to fungicidal spray of Bavistin + Dithane M-45 and bagging of heads with which the germination was improved. Seed germination was considerably reduced in kharif 1987 lot mainly due to continuous rains during seed harvest stage.

3.2 Studies on insect pest pathogens in seed storage

(V.J. Shivankar and S.N. Singh)

Effect of organic materials on pest infestation and viability of stored cowpea and sorghum

Cowpea var. IGFRI-450 and sorghum var.HC-136 seeds having initial moisture content
of 8.5 -10.5% and germination percentage of 96 and 94, respectively treated with petroleum ether extracts of *Nerium odorus* roots, *Melia azadirachta* bark, *Acorus calamus* rhizomes, *Croton tiglium* seeds, *Artemisia vulgaris* leaves, *Plumbago zeylanica* whole plant @ 2.5, 5.0 and 7.5 g/kg seed and malathion 50EC @ 0.08, 0.12 and 0.16 ml/kg seed, were stored in plastic containers at room condition. Five pairs each of *Callosobruchus chinensis* in cowpea and *Trogoderma granaria* in sorghum per 100 seed were released. A control was run simultaneously. Observations on moisture content, germination percentage, insect pest and pathogen infestations were recorded periodically.

In general moisture content tended to increase (upto 12.5%) during 6-12 months (July-Dec.) of storage in both crop seeds, which may be due to higher RH availability during the period. However, germination dropped below 75% in all the treatments at low concentration (2.5 g/kg) except in malathion (0.08 ml/kg) during next 3 months of storage of both cowpea and sorghum. While *C. tiglium* and *A. calamus* extracts at 5.0 and 7.5 g/kg and malathion at 0.12 and 0.16 ml/kg could retain germination above 75%. Rest of the treatments were effective only at higher levels (7.5 g/kg seed) for a period of 12 months. Whereas, in control there was about 50-60 and 85-95% viability loss at the end of 6 and 12 months of storage respectively.

Among all the treatments, *A. calamus*, and *C. tiglium* when applied @ 7.5 g/kg seed and malathion 50EC @ 0.16 m/kg seed offered safe storage with least seed damage (8.4 - 11.0%) by *C. chinensis* in cowpea and *T. granaria* in sorghum and higher germination percentage (more than 75%) for a period of 12 months of storage. On the other hand seeds stored without treatment suffered 100% seed damage by the insect pests at the end of 9 months and also lost viability to the extent of 60 and 95% at the end of 6 and 12 months of storage, respectively.

Effect of different containers on germination, moisture content and pest infestation

Sorghum var. HC-136 and cowpea var. IGFRI-450 with initial moisture content from 9.5 to 10.0% and germination 96 and 97% respectively were stored in various types of containers viz. plastic, metal, tin, gunny bags, cloth bags and double layer polyethylene (700 gauge) bags and maintained at room conditions. Five pairs each of *Callosobruchus chinensis* in cowpea and *Trogoderma granaria* in sorghum per 100 seed were released. Another set of experiment with three containers and three fungicide combinations (Thiram + Bavistin, Bavistin + Dithane M-45 and Thiram + Dithane M-45) along with control was conducted simultaneously. Observations on moisture content, germination and pest infestations were recorded periodically.

It was observed that seeds of cowpea and sorghum having less than 10% moisture content when stored in polyethylene bags for a year were found least damaged (9 to 10%) by insect with lowest infection with storage fungi and retained higher level of germination (84-88%). On the other hand seeds stored in cloth or gunny bags were severely damaged (33-77%) by insect pests and storage fungi with a decrease in germination to the extent of 20-30 per cent.

Further it was noted that seeds treated with Thiram + Bavistin were having low incidence of storage fungi as compared to other combinations and the effectiveness of these fungicides further increased when they were stored in polyethylene bags upto a year.

Effect of varying seed moisture and temperature on seed health in storage

The experiment comprising of two temperatures (20° ± 2°C and room temp) with and without neem powder on sorghum seed having initial
moistures content of 9% was conducted.

Seed viability at the end of 10 months declined (18-25%) in case seed was stored at room temp as compared to that stored at $20^\circ \pm 2^\circ$C (10-12%). Seed stored at $20^\circ \pm 2^\circ$C with neem leaf powder had lowest insect population and storage fungi as compared to room temperature where the increase of moisture content was upto 13.5% during July-Sept. This increase in seed moisture favoured a small population of *Sitotroga cerealella* and *Trogoderma granaria* indicating the presence of viable eggs on seeds prior to storage.

The frequency of storage fungi like *Curtularia lunata*, *Aspergillus flavus*, *A. niger* and *Rhizopus stolonifer* were increased with the increase of moisture content. The initial germination percentage decreased progressively with decrease in values of vigour index and further decrease in emergence (41.5-58.2%) in field tests at the end of 10 months storage.

The observation on attributes viz. plant height (cms), number of branches, number of pods, number of seeds, seed weight (g) were recorded on individual randomly selected plants, grown under Breeder’s Seed Production Block allotted for cowpea var. NP-3. The ranges (means) for plant height, number of branches, number of pods, number of seeds and seed weight (g) were 60.0 - 260.3 (146.5), 2.0 - 9.0 (5.8), 8.0 - 31.0 (14.9), 99.0 - 455.0 (214.2) and 10.31 - 59.84 (22.57) respectively. Statistical tests showed significant differences while comparing with their mean values. This kind of trend in variation within a variety indicated wider spacturm of variability, which should be narrowed down to level of uniformity vis-a-vis the genetic purity through intensive selection programme.

4.2 Breeder’s seed production

(O.P.Dixit, G.K.Dwivedi and P.S.Tomer)

During rabi 1987-88, 60 kg breeder’s seed of Wardan variety of berseem was produced as per the allocation of the Ministry of Agriculture. In addition 60 kg seed of Wardan variety of berseem, 50 kg seed of Kent variety of oats, 146 kg seed of JHO-810 variety of oats and 900 kg seed of JHO-822 variety of oats were also produced, while during kharif 1988, 170 kg seed of NP-3 variety of cowpea and 90kg seed of MP chari were harvested.
DIVISION OF PLANT PHYSIOLOGY AND BIOCHEMISTRY

PPB-1: PHYSIOLOGICAL STUDIES IN FORAGE CROP IMPROVEMENT

1.2 Varietal screening and induction of drought tolerance in forages

(R.B.R. Yadava and R.K. Bhatt)

Various genotypes of sorghum (Sorghum bicolor L.) grown under field were screened for CSI, RWC, proline leaf temperature, diffusion and stomatal resistance and transpiration at incipient wilting stage of the crop. Data along with genotypes are given in Table-26. Leaf temperature was not much affected. However, based on these parameters, the genotypes viz, RIO x HD-1-P', 2', RIO x HD-1, M-13-1, J-6-2-1, HD-2, JS-22 and HD-1 are the comparative drought tolerance.

Four varieties of oats were given drought treatment by restructuring irrigation at 4 physiological stages i.e. tillering stage, jointing stage, 50% flowering stage and at seed development stage. Characters associated with seed yield were recorded at the time of harvesting (Table-27).

CSI, RWC and proline accumulation were higher in stress condition whereas RWC decreased. Similarly stomatal conductance and resistance were higher in stress condition of all the varieties but rate of transpiration was lower which helps to plant grow satisfactorily under stress situation. Green fodder and dry matter yields (q/ha) were influenced greatly with frequency of irrigations given at various stages. Overall, UPO-94, JHO-810 and IGFRI-3021 stand better under restricted soil moisture stress.

1.2 Salt tolerance in forages

(O.P.S. Verma)

Three pasture legumes viz. Stylosanthes scabra, Stylosanthes hamata and Macroptelium atropurpureum were studied under pot culture for salt tolerance at four salinity stress levels (0, 5, 8 and 11 Ece). Salinity levels were artificially created by dissolving sodium chloride and calcium chloride in the ratio of 4:1, in water equal of the saturation percentage of soil. Transpiration rates and herbage yield were reduced with the increasing levels of salinity in all three species. However, magnitude of reduction in these parameters varied from species to species and being minimum in Stylosanthes scabra, but increase in chlorophyll content was recorded with the increasing salinity levels in all species. Stylosanthes hamata could not survive beyond salinity level of 8 Ece. Whereas, Stylosanthes scabra was identified as the most tolerant legume as revealed by its survival and yield at highest level of salinity stress (11 Ece), with the negligible reduction in transpiration rates (Table-28).

1.3 Effect of growth regulators on flowering, seed setting and quality constituents in range legumes and grasses

(R.B.R. Yadava and N. C. Sinha)

A second year trial on siratro (Macroptelium atropurpureum) was laid out in the field to study the effects of vipul commercial product of (X-NAA) on growth, flowering, seed setting and quality constituents. Various concentrations viz., 0.05, 0.10, 0.20 and 0.40 per cent were sprayed on the foliage along with the control (water spray) after 40 days from sowing. Plant height, days to initial flowering, pod setting percentage, sugar content in flowers, photosynthetic pigments including carotene in leaves, yield and protein content in seed were recorded.
<table>
<thead>
<tr>
<th>Genotypes</th>
<th>CSI</th>
<th>RWC</th>
<th>Free proline</th>
<th>Leaf temp. (°C)</th>
<th>Diffusion resistance (S/cm)</th>
<th>Stomatal resistance (S/cm)</th>
<th>Transpiration (µg cm⁻² s⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R₁₀ x HD-1-P₁₀</td>
<td>2</td>
<td>78.73</td>
<td>1.490</td>
<td>34.6</td>
<td>23.27</td>
<td>0.775</td>
<td>0.226</td>
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<tr>
<td>R₁₀ x HD-1-1</td>
<td>1</td>
<td>86.52</td>
<td>2.720</td>
<td>35.1</td>
<td>26.50</td>
<td>0.804</td>
<td>0.293</td>
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<td>D-11-1-1</td>
<td>3</td>
<td>88.68</td>
<td>2.670</td>
<td>35.0</td>
<td>27.35</td>
<td>0.832</td>
<td>0.767</td>
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<tr>
<td>J-6-2-1</td>
<td>2</td>
<td>90.88</td>
<td>4.421</td>
<td>35.6</td>
<td>26.55</td>
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<td>R₁₀ x HD-1-P₇</td>
<td>2</td>
<td>84.61</td>
<td>3.527</td>
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<td>26.45</td>
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<td>0.821</td>
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<td>7</td>
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<td>35.9</td>
<td>20.85</td>
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<td>M-1-3-1</td>
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<td>88.16</td>
<td>2.304</td>
<td>35.6</td>
<td>23.60</td>
<td>0.691</td>
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<td>HD-2</td>
<td>2</td>
<td>84.43</td>
<td>2.086</td>
<td>36.1</td>
<td>28.76</td>
<td>1.372</td>
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<td>D-23-2-1</td>
<td>8</td>
<td>80.48</td>
<td>2.370</td>
<td>36.2</td>
<td>23.92</td>
<td>0.882</td>
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<td>D-19-2-1</td>
<td>3</td>
<td>92.05</td>
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<td>36.8</td>
<td>28.50</td>
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<td>4-1-1-4</td>
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<td>36.2</td>
<td>31.50</td>
<td>1.964</td>
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</table>

Table 26: Physiological parameters for screening of sorghum genotypes at 36.2°C air temperature and 2000 mole m⁻² S⁻¹ PAR grown under field conditions.
Table 27: Performance of oat cultivars under stress condition to physiological components

<table>
<thead>
<tr>
<th>Variety</th>
<th>Irrigation Stage</th>
<th>Days to irrigation/frequency</th>
<th>Green fodder (q/ha)</th>
<th>Dry matter (q/ha)</th>
<th>Plant height (cm)</th>
<th>Fertile tiller No.</th>
<th>No. of grain/ plant</th>
<th>Seed yield (q/ha)</th>
<th>1000 seed weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>JHO-810</td>
<td>Tillering stage</td>
<td>25/1</td>
<td>361.1</td>
<td>86.5</td>
<td>89.8</td>
<td>3.3</td>
<td>212</td>
<td>24.76</td>
<td>20.73</td>
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<td></td>
<td>Jointing stage</td>
<td>50/2</td>
<td>422.2</td>
<td>87.8</td>
<td>93.3</td>
<td>4.0</td>
<td>258</td>
<td>36.62</td>
<td>23.53</td>
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<td></td>
<td>50% flowering stage</td>
<td>75/3</td>
<td>455.5</td>
<td>95.6</td>
<td>94.4</td>
<td>4.0</td>
<td>280</td>
<td>39.08</td>
<td>22.86</td>
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<td></td>
<td>Seed development stage</td>
<td>100/4</td>
<td>433.3</td>
<td>83.7</td>
<td>95.0</td>
<td>4.0</td>
<td>245</td>
<td>41.20</td>
<td>24.23</td>
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<td>66.2</td>
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<td>27.00</td>
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<td>388.8</td>
<td>72.5</td>
<td>93.0</td>
<td>4.0</td>
<td>244</td>
<td>30.83</td>
<td>35.40</td>
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<td>Seed development stage</td>
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<td>433.3</td>
<td>78.7</td>
<td>98.0</td>
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<td>198</td>
<td>33.80</td>
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<td>IGFRI-3021</td>
<td>Tillering stage</td>
<td>25/1</td>
<td>294.4</td>
<td>75.1</td>
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<td>Treatment</td>
<td>Stylosanthes scabra</td>
<td>Stylosanthes hamata</td>
<td>Macroptilium atropurpureum</td>
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</tr>
<tr>
<td></td>
<td>Herbage yield g/plant</td>
<td>Chlorophyll mg/g FW</td>
<td>Transpiration µg/cm/second</td>
<td>Herbage yield g/plant</td>
<td>Chlorophyll mg/g FW</td>
<td>Transpiration µg/cm/second</td>
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<td>Normal soil</td>
<td>430.8</td>
<td>1.137</td>
<td>3.903</td>
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<td>1.267</td>
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<td>5 Ece</td>
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<td>1.288</td>
<td>3.841</td>
<td>206.1</td>
<td>1.309</td>
<td>2.110</td>
<td>177.0</td>
<td>1.338</td>
<td>2.248</td>
</tr>
<tr>
<td>8 Ece</td>
<td>327.3</td>
<td>1.348</td>
<td>3.717</td>
<td>71.06</td>
<td>1.459</td>
<td>1.448</td>
<td>136.6</td>
<td>1.399</td>
<td>2.026</td>
</tr>
<tr>
<td>11 Ece</td>
<td>308.4</td>
<td>1.429</td>
<td>3.530</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>81.5</td>
<td>1.438</td>
<td>1.974</td>
</tr>
</tbody>
</table>
Plant height was increased with increase in concentrations of the chemical in comparison to control plants. Early flowering was noticed but higher concentration (0.4%) delayed flowering in comparison to control because of excessive growth of the plants. Total number of flowers/main shoot and pod setting percentage were more in treated series being maximum in 0.2 per cent. Sugar content in flowers, pigments in leaves and protein content in seeds were increased in lower concentrations in comparison to control but highest concentration showed inhibition. Seed yield/plant and q/ha were also increased significantly up to 0.2 per cent beyond that decreased considerably, and this increase varied from 5-15 per cent over control. However, trend of the result was similar as it was observed in previous year with foliar application of vipul.

1.4 Physiological variability in forage crops and their manipulation for higher seed yield

(N.C. Sinha)

A field experiment was laid out on cowpea. Foliar application of KNO₃ (2.4 and 6%) alone and in combinations with P₂O₅ (2 and 4 kg/ha) were employed thrice at 10 days interval from flower initiation. Results revealed that foliar application of KNO₃ was apparently more effective than phosphorus in utilization of accumulated collar sugar to develop potential flower. Among various treatments, foliar application of KNO₃ (4%) + P₂O₅ (4 kg/ha) developed potential flower (4.2% sugar) besides enough sugar accumulation in roots (14.21%) and photosynthetic pigments in leaf (Chl-a 1.46, Chl-b 0.89 and carotene 0.86 mg g⁻¹ f.wt). This finally resulted highest number of seeds (83) per plant and gave highest seed yield of 4.06 q/ha as compared to control (1.80 q/ha). The effect of treatments was noted in order of 4% KNO₃ + 4 kg P₂O₅ > 2% KNO₃ + 4 kg P₂O₅ > 4% KNO₃ + 2 kg P₂O₅ > 2% KNO₃ + 2 kg P₂O₅ > 6% KNO₃ + 4 kg P₂O₅.

Experiment on berseem was laid out to find out the effects of phosphorus (0.20, 0.40, 0.60, 0.80, 1.00 and 2.00 kg/ha) on nutrient content, sugar synthesis and its utilizations, photosynthetic pigments and seed yield. Increasing concentrations of phosphorus (upto 100 kg P₂O₅) increased the sugar concentration of leaf, stem and collar at first cut and developed potential photosynthetic pigments (total chlorophyll 3.08 mg and carotene 0.84 mg g⁻¹ f.wt). A steep drop of sugar in collar of this treatment at 50% flowering indicated its efficient utilization in developing potential flower (12-12.5% sugar). Further the concentration of calcium (3.3%), magnesium (1.1%) and phosphorus (0.2%) rose to a high level at a basal treatments of 100 kg P₂O₅/ha. High concentration of these nutrient of 100 kg P₂O₅ treatments seemed to be associated with synthesis and translocation of sugar in reproductive integuments which developed higher number of potential flower to result 2.70 quintal more seed yield over control (5.72 q/ha).

A field experiment was laid out to evaluate the effect of foliar nutrient (2% KNO₃ and 2 kg P₂O₅/ha) over basal application of 100 kg P₂O₅/ha on lucerne crop. Six treatments (control, 2 kg P₂O₅ foliar, 80 kg P₂O₅ basal+ 2% KNO₃ foliar, 80 kg P₂O₅ basal + 2% KNO₃ foliar and 80 kg P₂O₅ basal + 2% KNO₃ + 2 kg P₂O₅ foliar) were made. Foliar application of KNO₃ (2%) and P₂O₅ (2 kg/ha) were applied twice at seven days intervals of flower initiation. Among various treatments, foliar application of KNO₃ (2%) with basal application of P₂O₅ significantly increased the sugar concentration of flower besides marked accumulation in collar and root region and thus gave 0.90 quintal more seed yield over control (1.85 q/ha). The effect of treatment was registered in order of 80 kg P₂O₅ basal + 2% KNO₃, 80 kg P₂O₅ + 2 kg P₂O₅ foliar, 80 kg, P₂O₅ basal + 2% KNO₃ foliar, 80 kg P₂O₅ basal + 2% KNO₃ foliar + 2 kg P₂O₅ foliar, 80 kg P₂O₅ basal, 2 kg P₂O₅ foliar.

1.5 Physiological basis of variations in growth and yield in forages

(O.P.S. Verma)
Six oat varieties namely IGFRI-3021, JHO-831, JHO-822, JHO-817, UPO-94 and JHO-851 were sown. Data on leaf area, leaf and plant dry weights were recorded at 15 days intervals, from 30 days after sowing till 100 days of plant growth and computed the physiological parameters, like Net Assimilation Rate (NAR), Relative Growth Rate (RGR), Leaf Area Ratio (LAR), Specific Leaf weight (SLW), Specific Leaf Area (SLA), Leaf weight Ratio (LWR) and Growth Rate (GR). The mean NAR for four stages of growth analysis varied from 24-57 mg dm\(^{-2}\) leaf area day\(^{-1}\). Variation in mean RGR were recorded from 35-57 mg g\(^{-1}\) day\(^{-1}\). SLA, LAR and LWR reduced with the advancement of plant growth. However, an increase in SLW was recorded with the advancement of growth stage. Higher values of mean NAR, RGR and SLW in variety IGFRI-3021 gave highest mean growth rate of 32.05 gm\(^{-2}\) day\(^{-1}\).

1.6: Studies on light relations and assimilatory functions in forage crops

(R.K.Bhatt)

The light utilization efficiency (LUE), intercepted photosynthetically active radiation (IPAR), leaf area index (LAI), specific leaf weight (SLW), net assimilation rate (NAR) and dry matter yield were evaluated in ten genotypes of *Cenchrus ciliaris* and seven genotypes of *Cenchrus setigerus* grown under rainfed condition. All the genotypes differ markedly with respect to LUE and varied from 0.69% (IGFRI-558) to 1.4047(IGFRI-3108) in *C. ciliaris* and 0.695% (IGFRI 1196) to 1.186% (IGFRI76) in *C. setigerus*. Significant linear relationship has been found between dry matter accumulation and IPAR, LAI and LUE. The biomass in term of dry matter yield was increased by light harvesting efficiency through increased assimilatory surface. The SLW was positively correlated with NAR. The higher Chl-a, Chl-b and R ratio in the genotypes of *C. ciliaris* predicting the maximum photosynthetic efficiency as compared to the genotypes of *C. setigerus*. All these morphological and physiological traits are useful for the preliminary evaluation of genotypes/cultivars for higher photosynthetic efficiency. However, IGFRI-3108, 678 of *C. ciliaris* and IGFRI-76, 77 of *C. setigerus* having high LAI and LUE considered to be better genotypes for higher productivity (Table-29).

Further twenty grass species were also studied for their photosynthetic pigments (Chl-a, Chl-b), carotene content, SLW and leaf water content at pre-flowering stage. In general, as the Chl a:b ratio decreased the total chlorophyll and SLW increased. High specific leaf weight of *Chloris gayana* L. and *Brachiaria dictyoneura* L. seemed to be subjected with no accountability of Chl-b on total chlorophyll showing shade adaptive features of these grass. While the high ratio of Chl a:b (3-5) and low Chl-b content on *Chrysopogon fulvus* L, *Paspalum notatum* L. *Setaria sphacelata* L. and *Brachiaria mutica* L. indicating the light adaptive features of these grasses. Some grass species (*Sehima nervosum* L., *Dichanthium annulatum* L., *Panicum antidotale* and *Bothriochloa intermedia* L.) had high quantity of chlorophyll specially due to high Chl-a content and medium Chl a:b ratio and SLW also indicating the features of high productivity under tropical environment.

1.7 Interaction of light interception and energy exchange on growth and development of forages under different cropping system

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

Some selected tree species were evaluated on the basis of physical and physiological parameters like transpiration rate, resistances for water vapour transfer and energy balance. The observations were recorded during noon hours on clear sky day in the month of Sept- Oct. 1988. The average air temperature, relative humidity and photosynthetically active radiation (PAR) were 33.23°C, 42.2% and 1535 \( \mu \text{E m}^{-2} \text{s}^{-1} \) respectively. *Bauhinia variegata*, *Hardwickia binata*, *Tectona grandis*, *Gliricidia maculata* and *Terminalia arjuna* showed high rate of water loss, which cooled the surrounding atmos-
<table>
<thead>
<tr>
<th>Characters</th>
<th>X₁</th>
<th>X₂</th>
<th>X₃</th>
<th>X₄</th>
<th>X₅</th>
<th>X₆</th>
<th>X₇</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf area index (LAI)</td>
<td>0.9436</td>
<td>0.8200</td>
<td>-0.2706</td>
<td>-0.1049</td>
<td>-0.2338</td>
<td>0.4188</td>
<td>0.8040</td>
</tr>
<tr>
<td>Intercepted photosynthetically active radiation (IPAR)</td>
<td>(X₂)</td>
<td>0.8083</td>
<td>-0.3821</td>
<td>-0.1695</td>
<td>-0.3612</td>
<td>0.5127</td>
<td>0.8080</td>
</tr>
<tr>
<td>Light use efficiency (LUE)</td>
<td>(X₃)</td>
<td>0.0401</td>
<td>0.3472</td>
<td>-0.0468</td>
<td>0.4218</td>
<td>0.9849</td>
<td></td>
</tr>
<tr>
<td>Specific leaf weight (SLW)</td>
<td>(X₄)</td>
<td>0.3976</td>
<td>0.2190</td>
<td>-0.4112</td>
<td>-0.0397</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Assimilation rate (NAR)</td>
<td>(X₅)</td>
<td>0.3891</td>
<td>0.0279</td>
<td>0.3471</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorophyll a+b</td>
<td>(X₆)</td>
<td>-0.2070</td>
<td>-0.0472</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorophyll a:b</td>
<td>(X₇)</td>
<td>0.4217</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table - 30: Variations in physical-physiological parameters of tree species

<table>
<thead>
<tr>
<th>Tree species</th>
<th>Leaf temp. (°C)</th>
<th>Transpiration (μg cm⁻² s⁻¹)</th>
<th>Stomatal Resistance (S/cm)</th>
<th>Diffusion Resistance (S/cm)</th>
<th>Energy absorbed (Q abs)</th>
<th>Energy lost by re-radiation (Q rad.)</th>
<th>Energy lost by transpiration (Q Trans.)</th>
<th>Energy lost/gained by convection (Q Conv.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <em>Terminalia bolarica</em></td>
<td>33.7</td>
<td>1.416</td>
<td>0.218</td>
<td>21.4</td>
<td>0.741</td>
<td>0.710</td>
<td>0.040</td>
<td>-0.009</td>
</tr>
<tr>
<td>2. <em>Gluecidia maculata</em></td>
<td>33.5</td>
<td>2.143</td>
<td>0.146</td>
<td>18.2</td>
<td>0.715</td>
<td>0.705</td>
<td>0.012</td>
<td>-0.002</td>
</tr>
<tr>
<td>3. <em>Ficus racimoza</em></td>
<td>32.1</td>
<td>1.402</td>
<td>0.272</td>
<td>21.2</td>
<td>0.748</td>
<td>0.691</td>
<td>0.074</td>
<td>-0.017</td>
</tr>
<tr>
<td>4. <em>Terminatia arjuna</em></td>
<td>33.3</td>
<td>2.020</td>
<td>0.189</td>
<td>19.5</td>
<td>0.803</td>
<td>0.719</td>
<td>0.077</td>
<td>0.007</td>
</tr>
<tr>
<td>5. <em>Gmelina arborea</em></td>
<td>33.5</td>
<td>1.914</td>
<td>0.178</td>
<td>20.7</td>
<td>0.752</td>
<td>0.712</td>
<td>0.047</td>
<td>-0.007</td>
</tr>
<tr>
<td>6. <em>Hardwickia binata</em></td>
<td>33.1</td>
<td>2.257</td>
<td>0.134</td>
<td>16.5</td>
<td>0.731</td>
<td>0.697</td>
<td>0.042</td>
<td>-0.008</td>
</tr>
<tr>
<td>7. <em>Butea monosperma</em></td>
<td>32.6</td>
<td>1.799</td>
<td>0.232</td>
<td>20.3</td>
<td>0.762</td>
<td>0.689</td>
<td>0.065</td>
<td>0.008</td>
</tr>
<tr>
<td>8. <em>Ziziphus jooba</em></td>
<td>30.4</td>
<td>1.807</td>
<td>0.222</td>
<td>18.4</td>
<td>0.750</td>
<td>0.666</td>
<td>0.068</td>
<td>-0.016</td>
</tr>
<tr>
<td>9. <em>Albizia lebbeck</em></td>
<td>31.6</td>
<td>1.440</td>
<td>0.309</td>
<td>22.8</td>
<td>0.734</td>
<td>0.692</td>
<td>0.052</td>
<td>-0.010</td>
</tr>
<tr>
<td>10. <em>Dalbergia sissoo</em></td>
<td>32.5</td>
<td>1.373</td>
<td>0.331</td>
<td>26.2</td>
<td>0.741</td>
<td>0.703</td>
<td>0.036</td>
<td>-0.002</td>
</tr>
<tr>
<td>11. <em>Pterospermum sp.</em></td>
<td>32.9</td>
<td>2.157</td>
<td>0.246</td>
<td>17.1</td>
<td>0.724</td>
<td>0.696</td>
<td>0.030</td>
<td>-0.002</td>
</tr>
<tr>
<td>12. <em>Bauhinia variegata</em></td>
<td>34.9</td>
<td>2.261</td>
<td>0.212</td>
<td>16.7</td>
<td>0.833</td>
<td>0.716</td>
<td>0.105</td>
<td>0.012</td>
</tr>
</tbody>
</table>
phere and also helped in lowering evaporation of water from the soil surface. On the other hand, *Dalbergia sissoo, Albizia lebbeck, Terminalia blarico* and *Ficus racimosa* restricted water loss from the leaves and therefore, would tolerate more moisture stress conditions for survival. The trees with high diffusion and stomatal resistance for water vapour transfer exchange less water vapour as compared to those having low resistances.

The leaf energy balance sheet of these species showed that most of the energy absorbed was lost by reradiation and resulted in negative flow/ lower flow of convectional energy which indicates that most of these trees would be able to survive in the environments with considerable high air-temperature (Table 30).

1.8 Standardization of organ and tissue culture of trees

(L.P. Misra)

Attempts were made to micro-propogate true plant types from the shoots, leaf and nodal segments of a sterile hybrid tree of subabool (*Leucaena leucocephala* x *L. pulverulenta*) an interspecific hybrid developed at this Institute. *In vitro* shoots were regenerated on Murashige and Skoog's semi-solid (agar 0.8%) medium supplemented with IAA and kinetin. Rate of callus growth and shoot multiplication was enhanced when concentration of sucrose was increased from 3 to 4% in the culture medium, 6-benzylaminopurine at 1 mg/l increased callus growth to two-fold when added in the basal MS medium. Naphthalene acetic acid (NAA) at 1 mg/l and 2 mg/l did not allowed callus cells to regenerate into normal plantlets (Table 31).

**Table-31: Callus growth and shoot differentiation in different media**

<table>
<thead>
<tr>
<th>Medium</th>
<th>Responses on</th>
<th>Callus</th>
<th>Shoot differentiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. MS basal medium</td>
<td>SCG</td>
<td>SCG</td>
<td></td>
</tr>
<tr>
<td>2. MS + 1 AA (0.1 to 5.0 mg/l)</td>
<td>SCG</td>
<td>NSD</td>
<td></td>
</tr>
<tr>
<td>3. MS + Kinetin (0.1 to 2.0 mg/l)</td>
<td>MCG</td>
<td>SSBF</td>
<td></td>
</tr>
<tr>
<td>4. MS + BAP (0.1 to 2.0 mg/l)</td>
<td>MCG</td>
<td>SSBF</td>
<td></td>
</tr>
<tr>
<td>5. MS + BAP Kinetin (0.1 to 2.0 mg/l)</td>
<td>PCG</td>
<td>MSBF</td>
<td></td>
</tr>
<tr>
<td>6. MS (1/2 strength) + 4% sugar + BAP + Kinetin (0.1 to 2.0 mg/l)</td>
<td>PCG</td>
<td>MSBF</td>
<td></td>
</tr>
<tr>
<td>7. MS + BAP + Capentothenate + Biotin (0.1 mg/l)</td>
<td>PCG</td>
<td>PSBF</td>
<td></td>
</tr>
</tbody>
</table>

SCG Slow callus growth, NSD No shoot differentiation, MCG Moderate callus growth, SSBF Slow shoot bud formation, MSBF Moderate shoot bud formation, PCG Profuse callus growth, PSBF Profuse shoot bud formation
DIVISION OF PLANT PROTECTION

PP-1: STUDIES ON PLANT DISEASES, INSECTS AND NEMATODES AND THEIR MANAGEMENT FOR INCREASED FORAGE YIELD

1.1 Plant diseases of leguminous forages and their management

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

Survey

During surveys, heavy incidences of lucerne rust (Uromyces striatus), downey mildew of senji (Peronospora spp.), anthracnose of stylo (Colletotrichum gloeosporioides) and centrosema (C. gloeosporioides), bacterial blight of guar (Xanthomonas compestris cv. Cyamopsis) were observed. New diseases were top necrosis of lucerne (Fusarium equiseti), root-rot of berseem (Rhizoctonia solani and Fusarium semitactum) and leaf spot of leucaena (C. gloeosporioides).

Germplasm evaluation

Cowpea: Two hundred collections were screened against cowpea mosaic virus, anthracnose and leaf spot disease. Out of these 19 collections were found resistant to diseases.

Guar: Eighteen varieties were screened for resistance to bacterial blight (Xanthomonas compestris cv. Cyamopsis) and alternaria leaf spot (Alternaria cyamopsis). None was resistant.

Moth: Out of ten cultivars IL-1184 was highly resistant and IL-51 was tolerant to bean yellow mosaic virus (BYMV).

Lucerne: Three species Stylosanthes hamata, S. humilis, S. guanensis, S. scabra and S. viscosa were screened against anthracnose (Colletotrichum gloeosporioides). Of these S. viscosa was resistant and S. hamata was tolerant.

Lucerne: Out of 180 genotypes screened for resistance to common leaf spot (Pseudopeziza medicaginis) and rust (Uromyces striatus), none of was found completely free from the diseases. In pot experiments 12 annual species of Medicago and their genotypes were screened for resistance to root-rot (Fusarium sp., Rhizoctonia solani and Selerotium sp.). Medicago polymorpha, M. littoralis and M. intertexta were found resistant.

Control measures

Senji: Dithane M-45 (0.25%) and Bavistin (8.1%) were sprayed at 15 days interval for the control of downey mildew (Perenospora sp.). Data on disease severity and various plant growth parameters showed significant decrease in disease severity and corresponding increase in plant growth parameters.

Lucerne: Seed treatment with Thiram (0.15%), Bavistin (0.1%) and Dithane M-45 (0.25%) and their foliar sprays were applied for the control of foliar diseases. All treatments except seed treatment with DM-45 alone had reduced the disease severity significantly (5% level) over control (Table 32).

Biological: Seed of cowpea var. NP-3 were treated with Trichoderma harzianum and T. viridiflora and then sown in pots containing soil infested with Rhizoctonia bataticola. The data was recorded on plant disease index, fresh and dry weight and growth parameters. There was sig-
### Table 32: Chemical control of diseases of Lucerne (Medicago sativa L.)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Disease severity</th>
<th>Green forage yield/ga</th>
<th>% Increase in yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Seed Treatment with Bavistin + 1st spray of Bavistin @ 1%</td>
<td>0.33</td>
<td>92.77</td>
<td>40.07</td>
</tr>
<tr>
<td>2. Seed Treatment with Bavistin 0.1% + One spray of Dithane M-45 @ 0.25%</td>
<td>0.66</td>
<td>88.60</td>
<td>33.77</td>
</tr>
<tr>
<td>3. Seed Treatment with Thiram @ 0.25% + One spray of Bavistin 0.1%</td>
<td>0.66</td>
<td>86.38</td>
<td>30.42</td>
</tr>
<tr>
<td>4. Seed Treatment with Thiram 0.25% + One spray of Dithane M-45 0.25%</td>
<td>1.33</td>
<td>82.91</td>
<td>25.18</td>
</tr>
<tr>
<td>5. Seed Treatment with Dithane M-45 0.25% + One spray of Bavistin</td>
<td>1.66</td>
<td>81.52</td>
<td>23.08</td>
</tr>
<tr>
<td>6. Seed Treatment with Dithane M-45 + One spray of DM-45</td>
<td>2.33</td>
<td>78.74</td>
<td>18.88</td>
</tr>
<tr>
<td>7. Untreated seed + One spray Bavistin</td>
<td>2.33</td>
<td>77.36</td>
<td>16.80</td>
</tr>
<tr>
<td>8. Untreated seed + One spray DM-45</td>
<td>2.66</td>
<td>75.27</td>
<td>13.64</td>
</tr>
<tr>
<td>9. Seed Treatment with Bavistin</td>
<td>2.66</td>
<td>74.58</td>
<td>12.60</td>
</tr>
<tr>
<td>10. Seed Treatment with Thiram</td>
<td>3.00</td>
<td>72.66</td>
<td>9.70</td>
</tr>
<tr>
<td>11. Seed Treatment with DM-45</td>
<td>3.33</td>
<td>70.41</td>
<td>6.31</td>
</tr>
<tr>
<td>12. Untreated</td>
<td>4.66</td>
<td>66.23</td>
<td></td>
</tr>
<tr>
<td>C.D. 5%</td>
<td>1.157</td>
<td>6.369</td>
<td></td>
</tr>
<tr>
<td>C.D. 1%</td>
<td>1.573</td>
<td>8.657</td>
<td></td>
</tr>
</tbody>
</table>
significant reduction in the disease and corresponding increase in various plant growth parameters. *T. viridae* was most effective in increasing the number of nodules (369.58%) (Table-33).

**Lucerne leaf spot (Cercospora medicaginis):** Eight fungicides were evaluated *in vitro* by standard poisoned food technique for the inhibition of spore germination and mycelial growth. All the fungicides proved toxic at 500 ppm. At 100 ppm, Benomyl, Dithane M-45, Dithane Z-78 and Blitox completely inhibited the spore germination. Complete inhibition of mycelial growth was offered by Benomyl Carbendazim and Captan at 100 ppm.

**Plant distillate fungi toxicity:** The volatile oils extracted from the leaves of six plants viz. *Lantana indica* (Verbenaceae), *Anisomeles indica* (Labiatae), *Ocimum canum* (Labiatae), *Trachyspermum ammi* (Umbelliferae), *Blumea aromatica* (Compositae) and *Eucalyptus globulus* (Myrataceae). The fungi toxicity to *Uromyces striitus* were tested by inhibition of spore germination test. Complete inhibition of spore germination was observed in case of *T. ammi* and *B. aromatica* oils. The *I. ammi* oil also inhibited the sclerotia formation and mycelial growth of *Sclerotium rolfsi*.

**Pathogenicity testing of new root-rot disease of berseem**

Samples collected from infected fields yielded *Rhizoctonia solani* and *Fusarium semitactum*. The Pathogenicity tests of the fungi were carried out on varieties Warden, BL-1 and BL-2. It was found that both the fungus were pathogenic but the disease severity was higher when both the fungus were inoculated together. Bavistin (0.1%) and Thiram (0.3%) seed treatment appeared effective for the control of the fungi.

1.2 Plant diseases of non-leguminous forages and their management

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

**Survey**

During routine surveys heavy incidences of *Colletotrichum graminicola*, *Gloeocercospora sorghi* and *Helminthosporium turcicum* on sorghum was observed. *Dichanthium* spp. and *Sehima nervosum* were heavily infected with rust(*Uromyces clignyi* and *Puccinia duthiae*). *Panicum maximum* was severely infected with blast (*Pyricularia* spp.). In Cenchrus, leaf spots were predominant. *Cephalosporium* leaf spots on oats being a new disease.

**Evaluation for resistance**

**Dichanthium:** In field screening, genotypes of 5 different species viz. *Dichanthium annulatum*, *D. papilasum*, *D. humilis*, *D. sericeum* and *Bothriochola x Dichanthium* (natural) were screened for resistance to rust (*Uromyces clignyi*). Only three genotypes viz. *D. annulatum* 585, *D. papilasum* 20B and *D. humilis* 19B were highly resistant.

**Oat:** Germplasm collections (600) were screened for resistance to leaf blight (*Helminthosporium avenae*) and *Cephalosporium* leaf stripe. Genotypes of American origin were susceptible to *Cephalosporium* stripe. The genotypes of *Avena barbata* from Canada and *Avena fatua* from USA were found resistant to leaf blight. Stem rust severity and incidence on varied genotypes were recorded. Few collections were free while on others severity and incidence varied. In seedling stage, JHO 851 was resistant to stem rust and crown rust (*Puccinia coronata-avenae*).

**Sorghum:** 105 germplasm collections of sorghum and six different species of sorghum
Table 3.3: Effect of seed treatment with *Trichoderma* spp. on Cowpea plant parameters.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Disease incidence</th>
<th>Plant height (cm)</th>
<th>Fresh Wt. (g)</th>
<th>Dry Wt. (g)</th>
<th>Nodule (No.)</th>
<th>Fresh leaf Wt. (g)</th>
<th>Dry leaf Wt. (g)</th>
<th>Dry Shoot Wt. (g)</th>
<th>Leaf stem ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <em>T. harzianum</em></td>
<td>1.80</td>
<td>(22.65)</td>
<td>57.23*</td>
<td>(5.31)</td>
<td>6.9</td>
<td>(7.47)</td>
<td>16.46</td>
<td>(212.92)</td>
<td>20.33</td>
</tr>
<tr>
<td>2. <em>T. viridae</em></td>
<td>1.20</td>
<td>(35.36)</td>
<td>63.16</td>
<td>(46.93)</td>
<td>7.48</td>
<td>(16.51)</td>
<td>24.7</td>
<td>(369.58)</td>
<td>26.40</td>
</tr>
<tr>
<td>3. Control</td>
<td>4.60</td>
<td>46.66</td>
<td>36.86</td>
<td>6.42</td>
<td>5.26</td>
<td>17.23</td>
<td>20.1</td>
<td>3.22</td>
<td>3.13</td>
</tr>
<tr>
<td>C.D. at level of 5% significance 1%</td>
<td>5.13</td>
<td>3.59</td>
<td>0.46</td>
<td>2.34</td>
<td>2.26</td>
<td>1.29</td>
<td>0.52</td>
<td>0.41</td>
<td></td>
</tr>
</tbody>
</table>

*Figures are average of three replicates of 5 plants each, Figures in parenthesis are percent increase over control.*
were screened for resistance to Anthracnose (Colletotrichum graminicola), Zonate leaf spot (Gleocerospora sorgii), Leaf blight, (Helminthosporium turcicum) and Ramularia leaf spot. Only four genotypes of Sorghum vulgare, S. virgatum, S. alnum and S. helepense were resistant to these diseases.

Chemical Control

Sorghum: An experiment was carried out with Thiram, Bavistin and Hot water treatment in different combinations for the control of seedling and foliar diseases. All the treatments increased forage yield from 5-30% and 8-40% respectively. Significant increase in yield was due to seed treatment with Bavistin (0.1%) + two spraying of Bavistin followed by hot water treatment + two spraying of Bavistin, Thiram + two spraying and Bavistin seed treatment + one spraying of Bavistin.

Oat: The fungicides, Thiram, Ziram, Bavistin, Dithane M-45, Dithane Z-78 copper oxychloride, Benlate and Difolatan were tested by standard food poison techniques in three different concentrations. At 2000 ppm all the fungicides were highly toxic to Helminthosporium avenae. At 500 ppm Bavistin, Thiram, Ziram and Dithane M-45 offered complete inhibition of mycelial growth. In spore germination test Thiram, Bavistin and Ziram at 100 ppm inhibited spore germination completely.

Effect of rust on quality parameters of Dicanthium annulatum: Leaves infected with four levels of Uromyces clignyi infection were analysed for various quality parameters. ADF, NDF, lignin, silica and acid insoluble ash were positively correlated with level of infection. Crude protein, cellulose, hemicellulose, chlorophyll and carotene were negatively correlated with level of infection.

Cephalosporium stripe - A new disease of oat

Plants showing one or more white to pale green stripes with diffused edges developed along the full length of the leaf blades and sheath. The stripes are darker and turned reddish brown. Stripe enclosure soon turned chlorotic or yellow. As plants approaches maturity the stem areas below the nodes become dark. Infected plants remain stunted. The causal organism was identified as species of Cephalosporium.

1.3 Insects associated with leguminous forage and their management

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

Prevalence of Insect-pests and their natural enemies lucerne: Thirty pest species were recorded in lucerne from seedling to seed formation stage. Out of these, major pests were spotted alfalfa aphid, Therioaphis maculata remained active from January to April; lucerne weevil, Hypura postica remained active from January to March; Spodoptera exigua was active from April onwards and seed Chalcid, Bruchophagous roddi started at pod formation stage and caused considerable losses.

Cowpea: The major insect-pests on variety NP-3 were Galerucid beetle Madurasia obscurella causing damage in 15-71 days old crop. The jessid, Amarasca kerri remained active from 22 to maturity while the semilooper Plusia orichalcia and leaf miner Acrocerops phaespora at seedling and vegetative stage of the crop. Semilooper, Plusia nigrisigna highest population was seen in 57 days crop. At the flowering stage blister beetle Mylabris pusulata is the major pest.

Evaluation for tolerance to insect-pests

Lucerne: Twenty plants of IL-40, 49, 1418, Lahontan and Moapa showed degree of tolerance to spotted alfalfa aphid and lucerne weevil.

Cowpea: Out of 300 lines evaluated high yielding selections Hy 8P_60-12, Hy 8P_60-4, Hy 6P_32-3 and Hy 6P_32-6, IFC-8503 and UPC-8701 were tolerant to jessids and flea beetle.
Behaviour of spotted alfalfa aphid (SAA) on *Medicago* spp.

An experiment was conducted in the laboratory for observing the behaviour of SAA. The per cent nymphal mortality was highest in *Medicago rugosa* i.e. 5, 81, 85 and 98 per cent after 1, 4, 8 and 12 days feeding. The mean number of offsprings produced by 5 adults in 5 days were lowest in *M. rugosa* (1.0). The total life period was maximum in *M. rigidula* of 21.5 days as compared to lowest of 17.1 days in *M. polymorpha vulgaris*. On the basis of mortality and aphid development period, the species *M. rugosa, M. scutellata, M. turbinata* and *M. orbicularis* were classified as resistant, *M. hispida, M. rigidula, M. truncatula* as moderately resistant, *M. calcinata, M. litorallis* and *M. polymorpha vulgaris* as moderately susceptible and *M. sativa, M. orbicularis, M. ciliaris, M. murex* and *M. arabica* as susceptible.

**Chemical control**

**Lucerne:** The efficacy of 6 different insecticides viz. Decamethrin (0.003%), Cypermethrin (0.01%), Endosulfan (0.05%) and Monocrotophos (0.04%) were compared for the control of spotted alfalfa aphid. Decamethrin, Cypermethrin, Phosphomidon, Fenvalerate, Endosulfan and Monocrotophos gave 85.25, 85.39, 75.35, 74.63, 72.89, and 73.15 per cent mortality of the aphid after 10 days of 1st spray and 85.54, 83.06, 79.54, 80.33 and 80.31 per cent after 10 days of 2nd spray. Endosulfan showed average least mortality of 59.06 per cent as compared to highest in Cypermethrin 73.44 per cent. Pooled data of all observations indicated efficacy of insecticides as Decamethrin > Cypermethrin > Phosphomidon > Fenvalerate > Endosulfan > Monocrotophos.

In another laboratory experiment, the safety margin of four insecticides for the adults of *Bathyplectis curculionis* a predator of alfalfa weevil, *Hypha postica* was determined by the bioassay technique. The LC₅₀ values of Fenvalate was found to be least i.e. 0.000214% followed by Permethrin, 0.000228%, Cypermethrin 0.000258% and Thiodan 0.000032%.

**Cowpea:** Decamethrin was the most effective treatment in reducing the population of galerucid beetle and leafhoppers in cowpea followed by Cypermethrin, Fenvalerate and Thiodan with a population reduction of 82.41, 77.13, 73.12 and 48.74 per cent over control respectively in case of galerucid beetle, for leafhopper, the population reduction was 93.49, 82.69, 92.53 and 88.2 per cent over control respectively. Decamethrin (0.009%) gave maximum fodder yield of 328 q/ha as compared to Cypermethrin (0.009%), 316 q/ha; Fenavalente (0.009%), 307 q/ha; Thiodan (0.03%) 302 q/ha. The untreated control recorded lowest yield of 222.5 q/ha.

**Influence of intercropping on population dynamics of insect on cowpea**

Intercropping of cowpea with sorghum caused a considerable impact on the succession and population build up of insect-pests of cowpea. The population build up of galerucid beetle was not influenced by intercropping of sorghum. Leaf hopper population was 50.40/plant in sole crop as compared to 36.57/plant with sorghum. Leaf miner incidences were 9.84/plant in sole crop as compared to 5.93/plant with sorghum. There was delay in appearance of semi-looper by 10 days in cowpea when intercropped with sorghum. Population of wasps and ants was not affected by intercrop. Population of spiders increased in cowpea as sole plant (0.52/plant) as compared to cowpea with sorghum (0.42/plant). Coccinellid population was higher in cowpea and sorghum (0.23/plant) and in cowpea alone it was (0.12/plant).

1.4 Insects associated with non-leguminous forages and their management

(S.A.Faruqi and K.C.Pandey)
1. Insect pests succession predator/parasite association

**Sorghum:** Shootfly *Atherigona soccata* appear in July and remain up to October with maximum infestation up to 85% during August. *Aprostocetus* sp., *Tetrastichus* sp. and *Crataepilla* sp., were the parasites. Stem borer *Chilo zonellus* appear during the July and remain up to September with the peak activity during late August. *Apanteles flavipens*, *Odontepyris* sp., *Chelonus* sp., *Bracon albolineatus*, *Telenomus* sp., *Trichogramma* sp., *Stermiophis inferens*, *Bracon inhibitor* were the parasites. Aphid *Rhopalosiphum maidis* appears in August and remains up to September. Important predators were *Coccinella septumpunctata*, *Menochilus sexmaculatus* and *Episyrphus bateatus*. Sorghum midge, *Contarinia sorghicola* appear during August and remain up to the October. The parasites were *Apanteles* sp., *Eupelmus popa*, *Tetrastichus* sp., *Orius* sp.

**Mustard:** The major pest, *Lipaphis erysimi*, appears in November and remains active up to February. The predators were *Coccinella septumpunctata*, *C. repanda*, *Monochilus sexmaculatus*, *Symnus nubilis* and *Episyrphus bateatus*. *Sorghum* midge, *Contarinia sorghicola* appear during August and remain up to the October. The parasites were *Apanteles* sp., *Eupelmus popa*, *Tetrastichus* sp., *Orius* sp.

2. Screening of germplasm

**Sorghum:** The promising source of resistant for important insect pest of sorghum in 215 germplasm were identified as follows:

I. Shootfly: IS 1052, 1059, 1219, 1243, 1261, 1563, 2139, 3307, 3608, 3609, 3742, 3949, 4034, 4117, 4228, 4310, 4526, 4730, 4813, 5287, 5436, 5801, 6018, 6057, 9188, 24389, 27952 (27 lines).

II. Leaf roller: IS 1105, 1213, 1243, 2194, 3236, 3243, 3252, 3443, 3609, 3742, 3949, 4290, 4310, 4378, 4474, 4771, 5262, 5731 (18 lines).

III. Stem borer: IS 643, 938, 1052, 1059, 1087, 1219, 1366, 1563, 1568, 2139, 2146, 2249, 2908, 3236, 4113, 4342, 4636, 4746, 5604, 9188, (20 lines).

IV. Midgefly: IS 2123, 4328, 4756, 4837, 5251 (5 lines).

**Safflower:** One hundred and thirty three lines of *Carthamus tinctorius* were evaluated for reaction to aphids *Uroleucon compositae*. The aphid infestation ranged from 10.3 aphids/plant in IM 83-23 to 46.7 in IM 76-84-1. The correlation between morphological characters and number of plant was non significant.

3. Pest Management

**Chemical control**

**Sorghum shootfly:** All four insecticides (Cypermethrin, Decamethrin, Fenvalerate and Thiodon) tested at different concentration, proved better than the untreated. Among the insecticides, the treatments with Fenvalerate (0.009%), Decamethrin (0.006%) and Cypermethrin (0.009%) were at par. Fenvalerate treatment also gave maximum fodder yield.

**Mustard aphid:** Six insecticides (Cypermethrin, Decamethrin, Fenvalerate and Thiodon) tested at different concentration, proved better than the untreated. Among the insecticides, the treatments with Fenvalerate (0.009%), Decamethrin (0.006%) and Cypermethrin (0.009%) were at par. Fenvalerate treatment also gave maximum fodder yield.

**Safflower aphid:** A trial with five insecticides viz. Chlorpyrifos, Methyl demeton, Phosphamidon, Decamethrin and Cypermethrin to control aphid *Uroleucon compositae* in carthamus was conducted. All the five in-
secticides at two sprays were very effective. Among various treatments Cypermethrin proved to be best giving maximum aphid mortality (84.7%).

Cultural practices

Effect of date of sowing on the incidence of shootfly in sorghum: The results indicated that shootfly Atherigona sp. incidences were maximum (63.8%) in the crop sown on 30th July as compared to 33.8% and 41.2% in the sowing of 1st July and 16th July. The stem borer incidences were as high as 61.2% in all the sowing dates. The Carbofuran treated plots showed reduction in dead hearts upto 70% over untreated plots.

Effect of water logging on shootfly incidences in sorghum: M.P.Chari was tested for incidences of shootfly under waterlogged plots. It was noticed that the dead hearts count was increased by 38.16% in waterlogged plots as compared to well drained plots (60.45% and 22.29%).

1.5 Insects associated with range grasses and their management

(N.K.Shah)

Qualitative survey were conducted on different range grass species. It was noticed that all the species of range grasses are prone to the attack of grasshopper complex. Pennisetum polystachyon, Panicum maximum and Setaria sp. were found to be severely damaged by Hieroglyphus sp. Catantopes sp., observed to be on Pani­cum maximum and Cenchrus setegerus. Grasshoppers attack was found to be less in Sehima nervosum.

The Hieroglyphus sp., initiates during end of June and remains active till late October with a peak population built up during middle of August to middle of September. Atractomorpha sp. initiates during August and remains active till November with a peak population built up during September. Catantopes sp. initiates during September and remains active till November and with a peak population built up during September end and early October.

Few bugs and beetles were also noticed as minor pests of range grasses. 'Gundhi' bugs, Leptocorisa sp. were noticed to scur the earheads of Paspalum, Dicanthium and Panicum maximum. The immature earheads of Paspalum, Pennisetum and Veteveria were found to be damaged by an unidentified beetle. Stray incidence of leaf folder was also noticed on Panicum maximum and Cenchrus setegerus.

Predatory insects secies of Dragonflies, Damselflies, Robberflies and Reduviid bugs were observed, which are being identified.

1.6 Plant parasitic nematodes associated with herbaceous forages and their management

(N.Hasan)

Survey: During the survey, berseem fields in different locations showed circular bare patches of blighted plants with severe root-rot. Soil and root samples were collected both from diseased and healthy plants and revealed high population of stunt nematode T. vulgaris (1200-1300/250 ml soil) alongwith two fungi, Fusarium semitactum and Rhizoctonia solani associated with high plant disease index (Table 34).

Disease complex: Fifteen days old berseem Wardan seedlings raised in sterilised soil were inoculated with fungi (3 units) and nematodes (1000) in 12 different combinations and replicated 8 times. There was greater reduction in plant growth when all the three organisms present together reproducing field symptoms. Nematodes, inoculated 15 days prior to
fungus, resulted in highest disease index (2.7) and reduction of plant growth (64.33% fresh, 66.39% dry weight). It is therefore, concluded that the prior presence of the stunt nematode *T. vulgaris* in high numbers make the plant more susceptible to *F. semitactum* and *R. solani* fungus.

Evaluation of germplasm for resistance

Forty genotypes representing 13 annual *Medicago* species along with a common lucerne (*M. sativa*) and 16 ex-adic lines of *A. sterilis* were screened against *P. Zeae* and *M. Javanica* respectively in pot cultures. On the basis of reproduction factor (R = Pf/Pi), number of lesions and galls produced, resistance and susceptibility were categorised.

Differences at both intra and inter specific levels in *Medicago* species and *A. sterilis* were observed. *M. turbinata*, *M. calcinata*, *M. soutel-lata* 3509 and *M. rugosa* 2665 against lesion and *A. sterilis* late, CI 83334 and 3823 were resistant (R = 0.9 - 1.6) against root-knot nematodes.

Biological control of root-knot nematode *Meloidogyne incognita* infecting cowpea

The effect of *Paecillomyces lilacinus* (a predacious fungi, parasitising nematode eggs) was tested against root knot nematode infecting cowpea variety HFC 42 -1 in pots. The treatments were: T1 = Neem cake + Fungus SO (fungi cultured on sorghum) 6 days prior to nematode; T2 = Neem cake + Fungus ST (fungi cultured on stylo) 6 days prior to nematode; T3 = Neem cake; T4 = Leucena leaves + Fungus SO 6 days prior to nematode; T5 = Leucena leaves + Fungus ST 6 days prior to nematode; T6 = Fungus SO 6 days prior to nematode; T7 = Fungus ST 6 days prior to nematode; T8 = Fungus SO +

**Table 34: Relationship of stunt nematode (*T. vulgaris*) with *F. semitactum* and *R. solani* in berseem rhizospheres**

<table>
<thead>
<tr>
<th>Fungal mycelium rating</th>
<th>Number of samples</th>
<th>Number of <em>T. vulgaris</em> Disease rating*</th>
<th>250 ml. soil (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abundant</td>
<td>Abundant</td>
<td>30/2.7 -4.00</td>
<td>1200 -1300</td>
</tr>
<tr>
<td>Moderate</td>
<td>Moderate</td>
<td>25/1.0-2.6</td>
<td>800 -1000</td>
</tr>
<tr>
<td>Poor</td>
<td>Poor</td>
<td>40/0.9</td>
<td>130 -450</td>
</tr>
</tbody>
</table>

*Based on a rating of 0= no infection to 4 = dead plants.*
nematode simultaneous; T10 = Fungus ST + nematode simultaneous; T11 = Nematode 6 days prior to Fungus SO; T12= Nematode 6 days prior to Fungus ST and T13 = Control (Only nematode).

*P. lilacinus* significantly reduced the nematode infection (32%) besides increasing the growth (38% in fresh weight, 59% dry weight). However, T1 and T2 further improved the plant growth and reduced nematode infection (37-46%). Organic manures enhanced the multiplication of the fungus resulting in high percentage of egg mass infection (56-76%).

**Biological efficiency of essential oils against M. incognita (in vitro)**

Essential oil content was separated by the hydrodistillation methods on clevenger’s apparatus. Different concentrations were prepared in 0.1% teepol liquid detergent which also serve as control.

The essential oil obtained from *Trachyspermum ammi* L. (sprague), commonly known as bishop’s weed proved most toxic. The per cent inhibition in the larval hatch in 0.25, 0.125, 0.062 and 0.031 per cent concentration was 100, 97, 91, 31.71 and 14.72 per cent respectively. Similarly the per cent mortality in 0.25 and 0.125 per cent concentration even after 6 hours of exposure was 100 and 52.16 per cent respectively.

**Integrated nematode control**

A field trial with 6 treatments consisting of Saw dust (30 q/ha), Carbofuran 3G and Aldicarb 10G @ 1% a.i. w/w as seed treatment and their combination were evaluated in berseem variety Wardan and oat var. OŚ-6.

All the treatments significantly reduced the nematodes population and improved the forage yield. Highest increase in fresh and dry forage yield of berseem (32.18 and 53.52%) and oat (28.05 and 46.03%) was recorded in sawdust treatment. However, the per cent reduction in nematode population was highest (65.56% in oat and 70.21% in berseem) in plots with Carbofuran treated seeds. Combined effect of sawdust and nematicides in reduced doses (@ 15 q/ha and 0.5% a.i.) produced the most desired effect both in reducing the nematodes population sufficiently below control and improved the forage yield.

Another field experiment on integrated nematode management of cowpea var. NP3 and cowpea intercropped with M.P. Chari was subjected to the following treatments : 1. Two deep summer ploughing (15-20 cm) followed by incorporation of neem kernel powder @ 15 q/ha (12 days before sowing), 2. Neem oil as seed treatment (1% w/w at the time of sowing), 3. Two neem oil sprays (1%) 25 days after sowing at the interval of 20 days.

The highest increase in green fodder (45.5%) and dry matter (64.2%) yield of cowpea was recorded when deep summer ploughing was combined with incorporation of neem kernel powder and two sprays of neem oil. This treatment also reduced effectively the root-knot infection (65%). In mixed cropping,, the nematode infection on cowpea was further reduced. However, nematode population around sorghum was not affected by cowpea (Table-35)

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

(Mujib I. Azmi)

During routine surveys and analysis of samples significant infestation of root-knot, root-lesion, stunt, spiral, lance nematodes were observed.

The new parasitic nematodes identified are:
Pusa Giant is less susceptible (but not immune) to root-knot nematodes.

1.8 Studies on suitable plant protection practices for integrated pest management in forages


Pest management in cowpea, sorghum, maize and bajra

An experiment was carried out in cowpea with sorghum, maize and bajra as intercrops and seven treatments, viz. seed treatment with carbofuran and neem oil @ 1%, seed treatment with carbofuran and neem oil 1% and untreated seed in 1:1 ratio, carbofuran seed treatment 1% + neem oil spray 5% once and twice along with untreated.

Tylenchorhynchus ismaili n. sp; Hopolaimus refereqi n. sp; Discolaimium rakebi n. sp; Thernenema panjabsinghi n. sp; and a predaceous lotonchus bundeli n. sp.

The effects of dry decomposed tree leaves and FYM on the multiplication of various nematodes were studied. Tree leaves compost of su-babool and sesbania and FYM were used. Maximum rates of multiplication of productions, bacterophagus and mycophagus nematodes were found in the soil which were mixed with 1/4 to 1/5 FYM.

The biology of root-knot nematodes on su-babool and Dolichos indicated that M. incognita takes 30-35 days and M. javanica takes 40-45 days to complete their life cycle during June to September. On Dolichos and Su-babool, M. javanica can tolerate high temperature and deceptions in field as well as in laboratories.

Pusa Giant is less susceptible (but not immune) to root-knot nematodes.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>*% reduction in nematode infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cowpea</td>
<td>Cowpea+Sorghum</td>
</tr>
<tr>
<td>1. DSP + NKP @ 15 q/ha</td>
<td>56.4</td>
</tr>
<tr>
<td>2. DSP + Neem oil ST (1%)</td>
<td>36.0</td>
</tr>
<tr>
<td>3. DSP + Neem oil spray (1%)</td>
<td>28.2</td>
</tr>
<tr>
<td>4. DSP + NKP + Neem oil spray</td>
<td>65.5</td>
</tr>
<tr>
<td>5. DSP + Neem oil ST + Spray</td>
<td>41.2</td>
</tr>
<tr>
<td>6. DSP</td>
<td>18.5</td>
</tr>
<tr>
<td>7. Control</td>
<td>-</td>
</tr>
</tbody>
</table>

DSP = Deep summer ploughing; NKP = Neem kernel powder; ST = Seed treatment

*Each value is a mean of 3 replicates of 10 plants each
It was found that all the treatments reduced the pest and disease incidences and improved the forage yield to a varying degree. Highest increase in forage yield and decrease in pest and disease incidence in all the crops grown either alone or in combination were observed in seed treatment (carbafuran @ 1% w/w) followed by the sprays at the interval of 20 days with neem oil irrespective of the treatment. However, in contrast the pest and diseases of sorghum, maize and bajra were not affected by cowpea. It seems that many photophilic insects avoid dwarf crops when they are shaded by taller crops. In case of soil borne pest and pathogens, it is probably due to the change in host status.
AE-1: STUDIES ON DENSIFICATION OF GRASSES AND CROP RESIDUES IN THE FORM OF WAFERS AND BALES WITH AND WITHOUT MOLASSES TO OPTIMISE THEIR TRANSPORT DISTANCE BY DIFFERENT MODES

(Jai Singh)

IGFRI Forage Densification Machine

The reciprocating ram type IGFRI forage densifying machine developed during 1987 was improved by incorporating modified design on feeding and typing mechanisms and brought to the status of a pilot industrial prototype.

System analysis of the transport capacity of train, truck and tractor trailer (Figure 1) shows transport capacity of these modes over loose grass, baled grass and manually pressed wheat straw. The corresponding saving in transport cost per tonne by train, by truck worked out to be Rs. 249 and Rs. 1053 in loose grass; Rs. 177 and Rs. 413 in baled grass and Rs. 55 and 278.

FIG. 1 EFFECT OF DIFFERENT DEGREES OF DENSIFICATION ON TRANSPORT CAPACITY OF DIFFERENT MODES
Feed pelleting

IGFRI feed pelleting machine could successfully pelletise berseem hay and tree leaves with mixture of barley/wheat bran in the proportion of 2:1 and wheat straw in the proportion of 1.25:1. The present model produced 80-100 kg pellets/day.

Identification of fodder surplus and deficit areas

Analysis of fodder resources in the state of Madhya Pradesh based on Agricultural Statistics 1984-85 revealed availability of 53147 thousand tonnes fodder from all sources (2366 x 10^3 tonnes from crop residues, 5756 x 10^3 tonnes from grazing area, 14050 x 10^3 tonnes from grasses and top foliage in forest areas, 9636 x 10^3 tonnes from sugarcane tops and 4.5 x 10^3 tonnes from edible weeds) against the estimated requirement of 79511 thousand tonnes. The deficit in 1984-85 was in the order of 49.6%. It is likely to go up by 57% in 1990, 65% in 1995 and 72% in 2000 AD. The surplus deficit data for each Division of Madhya Pradesh is given in figure 2.

AE 2: INVESTIGATIONS ON BERSEEM HAY MAKING

(Jai Singh)

Wilting

Effect of Layer Thickness and Drying Surface

Rate of moisture loss from berseem crop with respect to elapsed time in 7.5 and 15 cm thick layers on earthen floor and on stone slab floor is shown in figure 3 and 5 respectively. In both cases moisture loss was faster in 7.5 cm layer. The dry matter concentration in 7.5 cm layer reached to 50% in 39 hours on earthen floor whereas it took only 32 hrs on stone slab floor. When spread in 15 cm layer, the dry matter concentration increased from 16.1% to 48.4% in 36 hours and to 64.2% in 45 hours on stone slab floor whereas the dry matter concentration on earthen floor reached to only 46.4% in 45 hours (Fig 4 and 5)

Mechanical Drying

Results of three batches (January 25 to 29, February 1 to 5 and 9 to 13) on drying rate of wilted berseem using IGFRI Forced Air Batch Drier is shown in Fig 6. The average dry matter concentration reached from 50 to 84.8% in 36 hours with blowing of natural air for a total period of 36 hours. The cost of hay making including mechanical wilting and drying worked out to be Rs. 60 per tonne. The capacity of the drier was about one tonne dry hay per day.

AE.3: DESIGN AND DEVELOPMENT OF IMPROVED FARM IMPLEMENTS

3.1 Design and development of seed and fertilizer applications devices

(Jai Singh and P.S.Chattopadhyay)

Furrow opener for Tractor Drawn Seed-cum-Fertilizer Drill

A furrow opener for placing seed and fertilizer under rainfed condition in black and red soils of Bundelkhand region was developed and popularised among the seed drill manufacturers. It is basically an extended shoe type furrow opener comprising a replaceable wedge shape cutting blade, bottom wedged for pressing the soil and preventing clogging of seed and fertilizer tubes (Figure 7).

Seed and Fertilizer Metering Mechanism for Tractor Drawn Seed-Cum-Fertilizer Drills

This mechanism consisted of a feed roller, having engroved cups on the periphery, seed/
FIG. 2: DIVISION WISE FODDER SURPLUSES AND DEFICIT IN MADHYA PRADESH.
FIG. 3 EFFECT OF THE LAYER THICKNESS ON WILTING RATE OF BERSEEM HAY
FIG. 4 EFFECT OF THE LAYER THICKNESS ON WILTING RATE OF BERSEEM HAY

FIG. 5 EFFECT OF DRYING SURFACE ON WILTING RATE OF BERSEEM HAY
FIG. 6 EFFECT OF DRYING SURFACE ON WILTING RATE OF BERSEEM HAY

- O - O STONE SLAB FLOOR
- X - X EARTHEN FLOOR

LAYER DEPTH: 15 CM.

AIR DRY BULB TEMPERATURE, °C

RELATIVE HUMIDITY (%)

DRY MATTER CONCENTRATION, %

AIR TEMP, °C

DRYING PERIOD, HOURS
Fig. 7 Furro opener (extended shoe type) developed at I G F R I, Jhansi

Fig. 8 Seed and fertilizer metering mechanism developed at I G F R I, Jhansi
fertilizer feeding and delivery tubes (Figure 8). The feed cups are mounted on the axle driven by ground wheel through chain and spockets. The rate of discharge of fertilizer and seed is controlled by adjusting the gap between the seed and concave with the help of screw bars provided. The mechanism has been found suitable for wheat, gram, barley, oat, jowar, urd, moong and peas.

3.2 Development of Rotary Disc Mover for Berseem and Oat Crops

(P.S. Chattopadhya And Jai Singh)

The bevel angle of the rotary blade made of high carbon steel fixed on the disc were varied from 15° to 40° in six step i.e. 15°, 20°, 25°, 30°, 35° and 40°. This unit was tested in field condition for berseem harvesting. The maximum clean and smooth cut was obtained at 15° bevel angle and the quality of cut gradually deteriorated as the bevel angle increased. However, the cutting edge of the blade became dull very rapidly at 15° and 20° blade bevel angle due to wear and tear. Considering the quality of harvest and life of the blade, 25° blade bevel angle was found most suitable for harvesting forage crops, viz. berseem and oats.

AE.4: FEASIBILITY TESTING AND PERFORMANCE EVALUATION OF IMPROVED FARM IMPLEMENTS ON ACTUAL USERS FIELD

(Jai Singh and P.S. Chattopadhya)

The feasibility trials were conducted in nearby adopted villages (Lakara, Karari and Rund Karari) for sorghum in kharif. The package of improved implements consisted of Bullock drawn (B.D.) mouldboard plough, B.D. disc harrow, B.D. channel cun bund former, B.D. two row seed drills, single row weeder and Gujarat Agro sickle. The average yield achieved for sorghum was 18.2 q/ha against 13.5 q/ha by traditional methods.

Seed Drills: Two row IGFRI and CIAE B.D. seed cum fertilizer drill were evaluated for green gram, lentil, sesamum, mustard, sorghum and oats in laboratory and field conditions. Average crop stand/plant population per square meter achieved by IGFRI two row B.D seed cum fertilizer drill were 32.4, 34.4, 50.8, 31.6, 52.6 and 66.4 and that of CIAE two row B.D. seed cum fertilizer drill were 32.8, 32.2, 40.2, 25.8, 57.2 and 67.2 for green gram, lentil, sesamum, mustard, sorghum and oats. The performance of CIAE seed drill was not satisfactory for sesameum and mustard crop but for other crops both seed drills performance was quite satisfactory.

Improved Sickles: The improved sickles (Gujarat Agro) were evaluated for green gram, sesameum, sorghum and Stylosanthes hamata (grass) and its performance was compared against the local sickle. The average effective field coverage with Gujarat Agro sickle was 118.3, 133.3, 128.6 and 125 man hrs/ha and that for local sickle was 139.8, 136.9, 146.5 and 142.8 man hours/ha. The cost of harvesting for Gujarat Agro sickle was 2.6 to 15.4 per cent less than that for local sickle.

Multicrop Thresher: The multicrop thresher was evaluated for lentil, pigeon pea, mustard and safflower. The output capacity of the thresher was 82.88, 65 and 79 kg/ha and threshing efficiency was 97.2, 98.9, 98.7 and 99.2 for lentil, pigeon pea, mustard and safflower. For all the four crops tested, the broken grain, blower grain and spilled grain percentage were considerably low.

Plant Pit Digger for tree plantation: The commercial pit digging implement was evaluated against manual pit digging at Central Research Farm of the Institute. The capacity of the machine was found to be 0.9 min/pit against 48 min/pit for manual pitting at 3 m x 4 m spacing.
including the travel time. The depth and diameter of the pits were 1 m and 0.3 m respectively. The cost of operation in machine and manual pitting were found to be Rs. 0.75 and Rs. 1.25 respectively.

Tractor drawn rotary grass mower and improved sickle in grass harvesting: Tractor drawn rotary grass mower and improved sickle were tested in harvesting range grasses. The area covered by local sickle, improved sickle and tractor drawn rotary grass mower was 0.5, 0.5 and 4.0 ha, respectively. In September, highest cost of harvesting and raking was in mechanical method and lowest in improved sickle. The cost of harvesting per ha was Rs. 326.17, 364.53 and 451.50 by improved sickle, local sickle and rotary mower, respectively taking labour wages as Rs. 13.50/day and tractor and machine Rs. 52.50/hour.

In the month of November the cost of harvesting was Rs. 318.06, 364.26, 427 per ha by improved sickle, local sickle and rotary mower respectively. But the wastage in terms of left out stubbles was noted to the extent of 170 and 320 kg/ha in improved sickle and local sickle respectively. Thus the net cost of operation was lowest in rotary mower. The cost of harvesting was paise 11.23, 12.84 and 17.48 in rotary mower, improved sickle and local sickle respectively.
1.3 Economics of forage production and forage based animal production systems

1. Economics of Intercropping

(I.P.S. Yadav and S.N. Tripathi)

(i) Hybrid Napier + Bessem: In four cuts the green fodder production was 211 q/ha from hybrid napier and 542.2 q/ha from berseem during rabi 1987-88. The crop was uniformly fertilized with 20 kg N/ha and 80 kg P₂O₅/ha. The nitrogen was applied in two equal splits. Cost of production was worked out to be Rs. 3005.4/ha giving net income of Rs. 12059.20/ha. Cost benefit ratio was worked out to be 4.01 for mixed crop stand.

(ii) Hybrid Napier + Cowpea: The fodder production trial was conducted during kharif 1988. The fertilizer dose was given @ 10 kg N and 40 kg P₂O₅/ha. Green fodder yield to the tune of 290.4 q/ha and 83.7 q/ha was obtained from hybrid napier and cowpea, respectively. Cost and return analysis revealed that net income of Rs. 5859.84 was obtained with an input of Rs. 1621.56 and output of Rs. 7481.40 with a cost benefit ratio 3.61.

2. Cowpea seed production

(I.P.S. Yadav and P.S.Tomer)

From the statistical analysis of two years data of cowpea it was found that results were same for both the year. In both the cases only varieties and phosphorus doses were significant at 1% level. All the interactions were non significant. The best yielding variety was V₃ (N.P.3) which was significantly different from V₁ (IFC 8401) and V₂ (IFC 8402). Varieties V₁ and V₂ did not differ from one another significantly. Presence of P in any dose produced a significant response but the two doses of P did not differ from one another significantly.

To see the impact of P doses on varietal yield, production function equations were tried by polynomial regression technique and the equation Y= a + b₁ P + b₂ P² was found fit for all the varieties. The optimum doses of P for V₁, V₂ and V₃ were 56.8 kg/ha, 46.6 kg/ha and 53.4 kg/ha, respectively and corresponding optimum yields were 8.8 q/ha, 7.4 q/ha and 13.4 q/ha. Comparing the profits obtained at optimum level of P use and maximum level, it was found that increase in profit at optimum level over maximum level were Rs. 9/ha Rs. 6/ha and Rs. 59/ha for V₁, V₂ and V₃ respectively.

3. Economics of sown pasture production

(I.P.S. Yadav and P.Rai)

Cenchrus setigerous + legume intercropping

The trial was carried out by the Grassland Management Division to know the effect of fertilizer, Azospirillum and intercropping of legumes as treatments on the productivity of Cenchrus setigerus to get higher production and economic returns. Treatments were significant at 1% level only for 2nd, 4th and 5th cuts, respectively. The coefficients of variation for the five cuts were 22.7, 36.2, 47.8 19.7 and 22.9% respectively. The CD value for 2nd, 4th and 5th cuts were 0.87, 0.97 and 1.32, respectively at 5% level. Economic analysis showed that
Azospirillum treatment + 20 kg N/ha was more beneficial followed by Stylosanthes hamata, Cajanus cajan. The highest cost-benefit ratio was 2.25.

1.4 Economic studies of intercrops and nitrogen levels on fodder production of winter maize

(R.A. Singh and S.D. Gupta)

The experiments were conducted at C.R. Farm by Agronomy Division during winter 1987-88. The treatment consisted of maize alone, maize + oat (single cut), maize + oat (two cuts), maize + Pisum arvens and maize + Lathyrus sativa with three levels of nitrogen (40, 80 and 120 kg N/ha.)

The analysis of variance of the data for green forage production revealed that the main effect of nitrogen and maize crop mixture were significant at 1% levels of significance. The nitrogen and crop mixture interaction was significant at 5% level of significance. The use of square (SS) due to main effects of nitrogen and crop mixture for forage production were further split into linear and quadratic components of single degree of freedom to decide upon the response curve to be fitted.

The dose response relationship for forage production was quadratic for maize + Pisum arvens and maize + Lathyrus sativa and other three were linear in response. The percentage of variation explained due to fitted relationship was over 99 per cent (Figure 9).

Cost benefit ratio and net profit was maximum in maize + Lathyrus sativa (1.99, Rs. 7282.19) followed by maize + Pisum arvens (1.53, Rs. 5569.31).

![Graph showing dose response relationship for forage production]

**FIG. 9** THE DOSE RESPONSE RELATIONSHIP FOR FORAGE PRODUCTION.
1.5 Production and Marketing of forages in Jhansi District

(Mallayya and I.P.S. Yadava)

The preliminary survey has been conducted in 4 villages of Jhansi Distt, where Institutes technology has been demonstrated. It was noticed that there are 230, 110, 200 and 125 farmers in Pahadi, Chappra, Chirula and Siyani villages respectively. Thus overall, total farmers were 665 only. There were 60 fodder producing farmers and from each village 15 farmers have been chosen from different categories.

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

(R.A. Singh)

1. Economics of crop production in Lakara-Karari Watershed area

Gram cultivation: In terms of area, total production and productivity, gram ranked first followed by wheat in all these villages. Production and economic analysis based on data of 51 sample farmers are shown in Table-36 A. Average production of gram ranged from 5.8 to 8.6 q/ha on the basis of villages and 6.4 to 10.0 q/ha on the basis of categories of farmers respectively. The average maximum yield of gram obtained by the nine marginal farmers was 10.0 q/ha with the cost of production of Rs. 2334/ha and the net profit per hectare Rs. 2043.16. The cost benefit ratio was 0.86. The cost benefit ratio of gram ranged from 0.24 to 0.86 and cost of production ranged from Rs. 2185.75 to Rs. 2598.87/ha on the basis of categories of farmers and village. The cost of production per quintal of grain and straw ranged from Rs. 220.23 to Rs. 362.46 and Rs. 14.68 to Rs. 24.15 respectively.

The fitted production function indicated that Cobb-Douglas production function is better than the multiple linear function. The Cobb-Douglas function explained about 0.2572 to 0.8743 of variation in $R^2$ whereas the multiple linear was a better fit for only Karari village farmers as whole showing 91% against 87% of Cobb-Douglas function as seen from the coefficient of determination. The elasticities of various input factors as measured by the corresponding regression coefficients in the fitted function were tested for their significance (duration from zero) for different villages and for different categories of the farmers of the project village. Cobb-Douglas function elasticity for seed alone for Lakara village, human labour and irrigation for Rund Karari village were found significant. Cob-Douglas and multiple linear function elasticity for seed, human labour and irrigation were found significant for Karari village.

In the case of marginal and small farmers Cobb-Douglas function was better fit with the coefficient of determination 0.3958 as against 0.3772 for multiple linear regression function. Elasticity of human labour and bullock/tractor power for marginal and small categories of farmers were found significant at 5% and 1% level. The elasticities of seed and human labour for medium farmers and only seed and fertilizer for big farmers were found significant.

Berseem: The average yield obtained by the farmers of command area was 695.7 q/ha as green fodder (Table 36-B) which ranges from 483.8 q/ha (marginal) to 758.5 q/ha (large farmers). The cost-benefit ratio ranged from 0.85 to 1.54. The average cost-benefit ratio was 1.36. The net return gained by the farmers was Rs. 9196.93 per hectare.

It was the highest gains to the farmers of watershed area in term of net return by the cultivation of berseem as a fodder crop. The output for the berseem has been taken as green fodder yield (converted in money value). The output has been taken as the gross return. The input for the crop was taken as cost in Rs/ha for seed ($b_1$), irrigation ($b_2$), human labour ($b_3$) and bullock/
Two types of relationship, namely multiple linear regression and Cobb-Douglas production function were fitted to the data. The fitted production function indicated that the Cobb-Douglas production function is better than the multiple linear function. The Cobb-Douglas function explains 78% of coefficient of determination, whereas the multiple linear function explains 77% coefficient of determination. Elasticity of human labour for berseem crop as green fodder was found significant.

**Mustard:** In the case of mustard grown by the farmers, the net profit and cost benefit ratio were lower Rs. 209.37 to Rs. 1697.06/ha and 0.11 to 0.69 respectively (Table 36-c). The average net return obtained by cultivation of mustard was Rs. 711.66/ha and the cost-benefit ratio 0.28.

**Groundnut:** Groundnut is the main kharif crop of the area. The return obtained from the groundnut by the farmers ranged from Rs. 1678.81 to Rs. 3096.50/ha. Maximum gain was obtained from the crop by marginal farmers of Rund Karari village, while maximum loss was obtained by marginal farmers of Karari village. The cost of cultivation ranged from Rs. 1697.15/ha to Rs. 3525.06/ha. The cost-benefit ratio ranged from -0.65 to 0.88 (Table 36-D).

The elasticities of various input factors as measured by the corresponding regression coefficients in the fitted function were tested for their significance for village Rund Karari separately and Rund Karari and Karari jointly. Cobb-Douglas and multiple linear function elasticity for irrigation alone for Rund Karari village at 5% level of significance and irrigation and bullock/tractor power were found significant for Rund Karari and Karari village jointly.

**Maize:** The average cost of production was Rs. 2594.98/ha and the return was negative Rs. 2074.67/ha. The cost benefit ratio was 0.80 (Table 36-E).

**Jowar:** In the case of sorghum crop for grain purpose grown by the farmers, the net profit was on an average lower than the other major crops of the area. The average grain yield obtained by the farmers was 7.65 q/ha with the cost of production Rs. 1535.12/ha. The net return and cost-benefit ratio ranged from Rs. 380.97 to Rs. 604.80/ha and 0.30 to 0.39 respectively. The maximum yield of grain (9.11 q/ha) and straw (17.68 q/ha) was gained by small farmers of Lakara village (Table 36-F).

**Urad and moong:** Urad and moong are the main pulse crops of the area. The average production of both crops are very low and it ranges from 1.25 to 2.18 q/ha and 0.63 to 3.25 q/ha, respectively. The return obtained by the crops were negative. The cost benefit ratio were also negative. It ranged from -0.65 to -0.48 and -0.81 to -0.18, respectively.

The output for the sorghum, urad and moong have been taken as the yield of grain and straws in q/ha (converted in money value). The output have been taken as the gross return. The input for the crops were taken as cost in Rs/ha for seed (b₁), human labour (b₂) and bullock/tractor power (b₃).

Cobb-Douglas function explain 0.45 to 0.70 of variation in R² whereas the multiple linear is a better fit for only sorghum crop showing 57% against 0.40% variation as seen from the coefficient of determination. Cobb-Douglas function elasticity for seed alone for moong crop was found significant at 1% level of significance. In the case of moong and urad, multiple linear regression function was found significant at 5% level of significance for seed and 1% level of significance for human labour.

2. Economics of demonstration crops in Lakara and Karari Watershed area

Fourty demonstrations were laid out on farmers fields during kharif 1988 in Lakara village. The demonstrations of forage consisted of
M.P. Chari (4), maize (6) Jower (7), moong (6), urad (10) and bhindi (7).

The M.P. Chari and maize for fodder performed better than the pulse crops, urd and moong. The cost benefit ratio and net return per hectare obtained by growing vegetable crop of bhindi were highest among all demonstrations (Table-37).

REB-2: BIOMETRICAL STUDIES IN FORAGE PRODUCTION AND UTILIZATION

2.1 Prediction model for productivity and growth of forage crops in relation to different soil parameters

(Ashok Kumar and C.R. Hazra)

The project has been completed and important findings are as below:

(i) For optimum yield prediction of cowpea, maize, and pearlmillet soil crust strength was found to be an important factor while seedling emergence in case of guar.

(ii) Study of linear and curvilinear regression technique revealed that for optimum yield prediction of a forage crop, curvilinear multiple regression equation viz. Square root for maize and Logarithmic (Ln) for pearlmillet were found, while for rest of the fodder crops sorghum, guar and cowpea, a multiple linear regression was found good in comparison to curvilinear.

(iii) After indexing different soil management practices, a study of path analysis was carried out and results indicate that soil management practices do not play any direct role in enhancing seedling emergence of forage crops, even though these practices influence seedling emergence of fodder crops vary much indirectly through soil crust strength and up to some extent soil moisture content. Soil crust strength and soil moisture content affects both directly and indirectly through each other to the seedling emergence of all the fodder crops viz. sorghum, cowpea, maize, guar and pearlmillet. Dry yield of these forage crops was also found very much effective by crust formation and moisture content in surface soil both directly and indirectly. Direct effect of seedling emergence of forage crops on their dry forage yield was found in very low quantum, while its indirect effect via soil crust strength and soil moisture content was observed quite high.

2.2 Distribution of yields in relation to size and shape of plots in forage crops

(Ashok Kumar and S.K. Rajpali)

From the data already collected in the units of 1 m x 1 m, on yield of stylo and oat under the project "Uniformity trials on forage crops" conducted on uniform piece of land of size 36 m x 36 m and 48 m x 36 m respectively at Central Research Farm of IGFRI, Jhansi, a frequency distribution was obtained for different size and shape of plots formed after combining the adjacent plots yield by taking 1, 2, 3...plots along row direction as well as in column direction. From these distribution different measures of variability like C V%, skewness and kurtosis etc. were determined for each combinations of plots. From this study results indicate that, with the increase in plot size there was a reduction in percent variability in yield of plots for both stylo and oat. The quantum of this variation in the yield of stylo for various plots combinations was varied from 3.45 to 30.0 % while for yield of oat, it was 3.25 to 26.33 %. By and large, the size and shape of plots for stylo and oat did not show any consistent trends on skewness and kurtosis to determine normality of the frequency distribution.
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<th>Net Return Rs/ha</th>
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<td>0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Urad</td>
<td>1973.38</td>
<td>61.28</td>
<td>0.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Lady's finger</td>
<td>3270.25</td>
<td>11806.19</td>
<td>3.61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 M. P. Chari</td>
<td>2289.85</td>
<td>560.15</td>
<td>0.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Maize A. Tall</td>
<td>1970.08</td>
<td>2021.21</td>
<td>1.03</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DIVISION OF EXTENSION AND TRAINING

Ext-1: ADOPTION AND DIFFUSION OF FORAGE INNOVATION AND FEED BACK INFORMATION

1.4 Lakara- Karari Watershed- A cross sectional analysis of the farmers for rural extension studies

(Mahavir Singh, Maharaj Singh and O.P.Singh)

Thirty respondents small, marginal and landless farmers in three villages Lakara, Karari and Rund Karari have been selected and each respondent interviewed personally. The tabulation of data on size of holding, education standard, occupation, cropping pattern, livestock, household assets, agricultural implements, social participation level, movement of farmers, technology transfer, media exposure and problems faced by farmers is in progress.

TRANSFER OF TECHNOLOGY

(i) Field Demonstration Programme

The Production Unit conducted demonstrations of improved forage production technology at the farmers fields. During rabi, 42 crop demonstrations of berseem + mustard and 15 of oat were laid in the nearby villages viz., Pahari, Palar, Tejpura, Simirdha, Hatnapur, etc. The average yield of berseem + mustard was 100.74 t/ha and for oat it was 45.69 t/ha green fodder. Similarly, during kharif 27 crop demonstrations of sorghum + cowpea, M.P.Chari + guar, sorghum + pigeon pea, maize, stylo and Dinanath grass were laid out in Pahari, Simirdha, Tejpura, Budha and Garaha villages.

(ii) Watershed based programmes

During the year, Institute remained associated with three watershed projects. The follow up programme continued in Tejpura watershed. The improved crop demonstrations comprising cereal, pulse, oilseed and fodder crops were laid under this programme.

Under National Watershed Scheme, Institute was nominated as a nodal agency to provide technical guidances.

In Lakara- Karari watershed, integrated approach of Crop Livestock development programme was undertaken in three villages i.e. Lakara, Karari and Rund Karari in collaboration with development departments of the Govt. of U.P.

a) Water-resource development: In this year boring of nine tube wells were done in the farmers field of which five were successful by discharging reasonable quantity of water.

b) Dryland crop demonstration: 26 crop demonstrations were laid down in the farmers field. These included sorghum (7), black gram (10), green gram (6) and til (3). Though it was a drought year since the rain stopped in the middle of September, it gave higher yield of about 25-50% than was obtained in the farmers field.

c) Vegetable crop demonstration: Demonstrations of Vegetable crops like ladiesfinger, brinjal, chillies and tomato was done. The result showed that ladiesfinger was highest yielder (30.5 q/ha) and highly remunerative.

d) Fodder crop demonstration: This year 18 fodder crop demonstrations were given. These included fodder crops of sorghum, maize, berseem, oats and lucerne.

e) Tree plantation in the farmers field: In this year 1350 trees were planted. These in-
cluded bamboo, mango, eucalyptus, aonla, guava and citrus fruits.

f) Tree planted in the forest land: Trees in 20 ha land were planted in the forest land by the forest department.

g) Soil fertility analysis: Since there was no adequate fruiting in mango and lemon trees in the farmers’ field, soil analysis was done for available N, K, P and organic carbon. It was found that N and org. carbon was low but P and K was adequate. pH was at neutral zone (7.4-7.8).

h) Crop diseases: Leaf spot, mosaic virus, yellow vein mosaic virus and leaf drying was most common in the vegetable plants. White ant attack was found in the trees planted recently.

i) Animal improvement: Treatment of sick animal (140 cases), castration of scrub bulls (21), vaccination against infectious diseases (4487), cattle and buffalo breeding (21) was taken up this year.

j) Farm machinery and implements demonstration: The package of improved implements consisting of bullock drawn mouldboard plough, disc harrow, channel-cum-bund former and two row seed drill and single row weeder and improved sickles (Gujarat agro) was demonstrated. The use of package resulted an increase of 35% over traditional methods in sorghum (13.5q/ha).

(iii) Outreach programme

The outreach programme continued at distant places to proliferate the technology generated at the Institute. The progress at various places is briefed below:

Sultanpur: The Institute in collaboration with NDUAT, Faizabad conducted 50 demonstrations in Ismailpur, Kotra, Dharpasor and Bharvasinghpur villages of the district. The average yield of berseem + mustard, oats and sorghum + cowpea were 91.67, 52.11 and 64.93 t/ha green fodder respectively.

Kanpur: In collaboration with CSA University, Kanpur 16 demonstrations of sorghum + cowpea during kharif and 10 demonstrations each on berseem + sarson and oats were laid in farmers’ field.

Faizabad: In user land a yield of 420.89 q/ha green fodder was obtained with para grass, guinea grass and Bothriochloa.

Hardoi: Different grasses planted in user land (6.6 ha) in collaboration with forest deptt. and Sarvodaya Ashram, the para grass gave an yield of 375.00 q/ha green forage.

Gwalior: Various grasses mixed with stylo were planted on 23 farmers field in collaboration with Gwalior Cooperative Milk producers Union Ltd.

Talbehat (Lalitpur): Development of wasteland programme initiated in 1986 in collaboration with forest department continued upto 1988. About 16 ha area has been covered with Stylosanthes hamata. The maximum dry matter (68.19 q/ha) was recorded in 1987 followed by 1986 (59.60 q/ha) and 1988 (40.00 q/ha).

Datia: For development of degraded lands, sowing of different grasses was demonstrated in small area and technical knowhow was arranged.

Bharari Farm: Rooted slips of C. ciliaris in 0.8 ha and S. hamata in 2 ha were planted under Institute guidance. The performance is quite satisfactory.

(iv) Exhibition/Field days

Around 3000 visitors were explained about the activities of the Institute. The participation in All India Farmers Fair (26-28 Feb. 1988) organised by CSAUT created awareness among farmers. Similarly, Institute also participated in Pulse Day (21.2.88) organized by CSAUT Campus, Bharari.

Institute also arranged 9 Field days, 4 at the Institute Campus and 5 in various villages where Institute crop demonstration programme has been taken up. In these field days, farmers were acquainted with the latest fodder production, grassland management, livestock feeding and use of improved agricultural implements.

(v) Farmers Training Programme

Besides diploma and short term training courses, approximately 750 Govt/Non Govt/ Voluntary Organization sponsored development workers/farmers were trained for 1 to 5 days. Few batches of farmers were also brought to Institute for training in forage production and utilization.

(vi) Literature and consultancy services

14 extension folders on different fodder crops were brought out during the year. A large number of enquiries were attended either through correspondence or personal visit/consultancy services.

TRAINING AND EDUCATION

Training

Diploma Course: Five Officers from various State Departments successfully completed 9 month Diploma Course on Forage Production and its Utilization during the year 1988-89.


Education

The Institute has been recognised as a Centre of research by Jiwaji University, Gwalior and Bundelkhand University, Jhansi for Ph. D. studies. During the year, three students were permitted for pursuing Ph. D. programme and two students were awarded Ph. D. degrees.
INTER-INSTITUTIONAL COLLABORATIVE RESEARCH

FARMING SYSTEM RESEARCH
(Panjab Singh and A. Rekib)

Under this project two sub-systems were taken.

1. Intensive fodder milk production system
2. Soil-Water plant-Livestock management system

In fodder milk production system, annual and perennial fodder crops were grown and fed to the dairy animals to study milk production and its economics.

In the soil-water-plant-livestock management system, 3 tier pasture, established pasture, improved and natural grassland and bare land (control) were studied for the soil and nutrient losses; soil changes and soil nutrient built up; pasture production; forage quality evaluation and livestock production. Economics of different management system was also worked out.

Research work conducted at Jhansi is presented below:

IICP-1. INTENSIVE FODDER MILK PRODUCTION SYSTEM

I/AG: Evaluation of intensive fodder production system for milk production

(Bhoori Singh)

During the period under report (a) annual fodder production system and (b) perennial cropping system were studied. In the annual fodder production system following three rotations were undertaken:

1. Sorghum (PC-6) + Cowpea (Russian giant) - Berseem (Warden) + Japan rape - Maize (AF) + Cowpea (RG)
2. Maize (AF) + Cowpea (RG) - Berseem (Warden) + Japan rape - maize (AF) + cowpea (RG)
3. Bajra (Wec.75) + Cowpea (RG) - Berseem (Warden) + Japan rape - Bajra + Cowpea

Green and dry fodder yields of kharif crops when harvested daily for feeding the dairy cows were 253.3 and 79.3 (Sorghum + Cowpea), 233.3 and 101.8 (Maize + Cowpea) and 182.5 and 55.5 q/ha (Bajra + Cowpea).

In perennial fodder production system, Hy. Napier IGFRI-3 + Cowpea has been grown. Hy. Napier was planted in lines with 4 different spacing (2.75 x 0.50 m and 2.50 x 0.50 m in paired rows; 2.75 x 0.50 m and 1.0 x 0.50 m single row). Cowpea has been sown in the interspace area. Total yield of green fodder was 230 q/ha. In rabi 88-89, berseem has been sown in the interspaces.

1/PAR: Milk production studies on fodder feeding system.

(V.C.Pachauri)

Two groups of dairy cows (control and experimental) with average yield of 9 kg were used in this experiment between February to May 1988. In June, the animals were fed berseem hay and short term experiment was conducted. Feeding practices and milk production are presented in Table 38.
Sorghum silage was prepared from excess of sorghum fodder and feeding was continued for about 2 months with 8 dairy cows giving an average 7.0 liter milk per day. Experimental group was fed 50% less quantity of concentrate mixture and DM consumption was 9.0 kg in control and 8.0 kg in the experimental group. It was found that the experimental and control group animal produced similar amount of milk 5.44 liter and 4.95 liter respectively.

### Table 38: Feeding practices and milk production/animal/day

<table>
<thead>
<tr>
<th></th>
<th>Feeds(kg/head/day)</th>
<th>Milk yield(lit/head/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Experimental</td>
<td></td>
</tr>
<tr>
<td>Concentrate</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Berseem</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Roughage</td>
<td><em>ad lib</em></td>
<td><em>ad lib</em></td>
</tr>
<tr>
<td>DM intake%</td>
<td>3.95</td>
<td>4.24</td>
</tr>
<tr>
<td>March</td>
<td>8.98</td>
<td>9.38</td>
</tr>
<tr>
<td>April</td>
<td>7.10</td>
<td>7.80</td>
</tr>
<tr>
<td>May</td>
<td>5.97</td>
<td>5.78</td>
</tr>
</tbody>
</table>

2/AE: Hydrology and sedimentation loss under different land use systems

(Jai Singh)

Studies on runoff coefficient and soil losses under 3 tier forage production system, sown pasture, improved and natural grassland and bareland (control) in the sandy loam soil at CIRG, Makhdoom and red gravelly sandy loam soil at IGFRI, Jhansi were conducted.

The result showed that maximum runoff coefficient of 0.3842 and soil losses of 7.8352 t/ha in the bare (control) while minimum values of 0.2543 and 0.8331 t/ha in 3 tier system were recorded at CIRG, Makhdoom. Similarly, maximum run off coefficient of 0.4940 and soil losses of 6.9032 t/ha in bare (control) with minimum values of soil losses (0.4870 t/ha) were recorded at IGFRI, Jhansi. In the red sandy loam soil of Jhansi highest available moisture content (11.30%) was recorded in the improved pasture but it was least (8.60%) in bare (control) plot.

2/SS: Studies on soil fertility changes in Rangelands under different systems of Soil-Water-Plant Livestock Management

(R.B. Yadava)

Soil fertility status of all the experimental plots was evaluated by collecting soil samples from two different depths i.e. 0-15 and 15-30 cm. The results indicated that the soils of the experimental area were sandy clay loam to sandy clay in texture and were of neutral pH 6.45 - 6.65. Organic matter content was very low (0.28 -
Other essential nutrients such as Nitrogen, Phosphorus and Potassium status was also very low. Phosphorus level ranged between 5.04 to 7.14 kg/ha. Nitrogen was higher in sown pasture (171.3 kg/ha) and it was lowest in the control (137.7 kg/ha) in bare land. Potassium content varied between 156.0 (in 3-tier system) to 118.1 kg K2O/ha in bare land.

2/NRCAF: 3-tier forage production system
(R.Debroy and M.M.Roy)

In the 3-tier production system *Acacia tortilis* and *Dichrostachys cinerea* exhibited better establishment (77.5 and 76.4%) as compared to *Leucaena leucocephala* (56.4%) in the 2nd year of growth. However *L. leucocephala* recorded better growth in terms of height and collar diameter (170.9 cm and 2.2 cm) as compared to *A. tortilis* (121.9 cm and 2.03 cm) and *D. cinerea* (93.6 cm and 1.6 cm). Highest dry pasture production was obtained in block I (7.77 t/ha) followed block IV (4.99 t/ha), block II (3.85 t/ha) and block III (3.39 t/ha) in that order. Higher pasture production in blocks I and IV was mainly because of better establishment of *Stylosanthes hamata*.

2/GM: Evaluation of different pasture production systems under Soil-Water-Plant-Livestock management system
(K.C.Kanodia)

Studies on the estimation of dry matter production were conducted through repeat quadrat method in enclosures maintained for the purpose in three types of pastures (established, improved and natural grassland).

Data revealed that the highest dry matter production (10.93 t/ha) was obtained in the established pasture, followed by 9.75 t/ha in the improved and 6.12 t/ha in the natural grasslands. The data on vigour in the 3-systems showed that the maximum number of tillers and height of tillers/plant were 124 and 125.35 cm respectively of *Sehima nervosum* in case of improved grassland as compared to 38 tillers and 79.2 cm height of same species, in case of the natural grassland. These parameters in case of *Cenchrus*, 57.0 tillers and 87.4 cm height were of a much lower order as compared to those of *Sehima* in case of previous two systems, possibly because *Sehima* plants in the earlier system are much older than those of *Cenchrus* in the sown pasture.

It was interesting to note that dry matter production of stylo (4.51 t/ha) in the first pasture as well as the overall production data for the 3 systems including the dry matter yield of grasses showed a significant increase during the present year as compared to the previous years.

2/PAR: Nutritional evaluation of sown and natural pasture
(N.C.Verma and A.Rekib)

Nutritional quality of sown and natural pasture was evaluated in the middle of September. Chemical composition indicated that sown pasture was better as it contained 7.79% crude protein. The natural grassland contained only 5.28%. The natural grassland also contained higher amount of silica and dry matter. Digestion trial conducted in sheep and goat under stall fed condition indicated that the intake of dry matter was higher in sown pasture (2.80) than that of the natural pasture (2.72 kg/100 kg w/w). Dry matter and organic matter digestibility was higher in the natural pasture, but these were not significantly different from sown pasture. Crude protein digestibility was 55.77% in sown pasture but it was only 38.50% in the natural grassland. It was also noted that dry matter, organic matter and crude protein digestibility were higher in goat.
The dry matter digestibility and intake study were also conducted under grazing conditions using internal indicator method. The study showed that DM intake and digestibility coefficient of dry matter and crude protein was similar to stall fed conditions. Thus in this laboratory, the dry matter intake digestibility coefficient of DM and CP of grazing animals has been standardised.

2/PAR: Haematological and trace mineral studies under different pasture conditions

(K.S. Ramachandra and A. Rekib)

Haemoglobin and packed cell volume of blood of sheep and goat grazed under sown pasture and natural pasture was studied. There was practically no difference in both the components. Copper, zinc and iron content of the herbage from the above two pastures were estimated and found to be 8.65 and 7.52 ppm for copper, 21.6 and 18.48 ppm for zinc and 86.0 and 82.8 ppm for iron respectively. Zinc and copper content of pasture were below normal requirements but iron content was adequate. Composition of copper, zinc and iron in the blood of the experimental animals showed that zinc and iron were more in sheep in the natural pasture but copper was more in goats.

2/WRS: Evaluation of different pasture production systems

(Fateh Singh)

In treatment T-0 (control) the soil ploughed with tractor drawn cultivator only one time and later the grass was allowed to grow. The soil losses will be high if it ploughed every time. There was no device to collect the water and soil. The grass was harvested with labours and weight was taken. The grass yield was 7.5 q/ha.

In treatments T-1 (natural grasslands) the land was left as such and no improvement was made. The grass was harvested with labours. The dry grass collected in the treatment was 12.3 q/ha.

In treatment T-2 (improved grassland), 20 kg nitrogen per hectare was applied in the form of urea in the months of July, 88. The seed (3 kg/ha) of Cenchrus ciliaris was broadcasted at time of good rain in the month of July. The grass was harvested and its dry matter yield was recorded. The dry matter yield of this treatment was 18.5 q/ha.

In the treatment T-3 (sown pasture), 40 kg N and 40 kg P₂O₅ per ha were applied in the form of urea and single super phosphate respectively. The grass Cenchrus ciliaris was sown @ 5 kg/ha. The seed was covered with soil by tractor drawn cultivator. The undesired shrubs, bushes and weeds were cleared by labours. The dry yield of grass in this treatment was 32.6 q/ha. The grass was harvested by labours.

In T-4 (three-tier-system) the saplings of Ailanthus exelsa and Dichrostachys nutans were raised. The data on survival percentage, height of plants and grass yield are given as under.

<table>
<thead>
<tr>
<th></th>
<th>Survival (%)</th>
<th>Height (m)</th>
<th>Collar Diameter (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ailanthus exelsa</td>
<td>87.5</td>
<td>84.5</td>
<td>4.2</td>
</tr>
<tr>
<td>2. Dichrostachys nutans</td>
<td>92.5</td>
<td>106.3</td>
<td>4.5</td>
</tr>
</tbody>
</table>

T-5 (common prevailing cropping systems) in which farmers grow guar 1st year and grow bajra 2nd year in the same field and rotate each crop year after year. The bajra produced 8.2 q/ha as seed and guar produced 8.0 q/ha. Guar gave a net return of Rs. 1002/ha while bajra yielded profit margin of Rs. 921/ha.
1. Varietal improvement

On the basis of crops and the varietal testing at 30 locations representing different agro-climates, a number of high yielding varieties of forage crops have shown promise for different regions (Table 39).

Based on the performances of last three years a number of varieties of different crops have been identified for their release (Table 40).

2. Agro-techniques for forage production

The herbage yield of many fodder crops and grasses improved by 8-22 per cent when crop seeds were inoculated with non-symbiotic nitrogen fixing organisms like Azotobacter and Azospirillum spp. to crops like sorghum, maize, guinea grass and buffel grass. Combined application of Azotobacter + Azospirillum was proved beneficial and increased maize forage yield by 22 per cent over control. Similarly, inoculation with Rhizobium meliloti (strain LJ-13) to lucerne crop helped in forage yield by about 20 per cent.

In case of barley, it is possible to harvest both green fodder and grain through harvesting the crop at 50-55 days for fodder and subsequently managed for grain. It is possible to obtain 140-250 q/ha of green forage followed by seed yields of 14-35 q/ha depending upon the environment and agro-climate. In some locations like north-west region and Chhotanagpur areas in east, the seed yield from cut crop was found to be 75 per cent of the un-cut crop. DL-36, DL-454 and K-141 were found to be suitable genotypes for cutting purpose. Application of 30 kg N/ha basally followed by similar dose after cut favoured in yield maximisation.

High density planting of maize at 25 cm row spacing followed by harvesting alternate rows at 50 days helped in obtaining both forage (393.0 q/ha) and seed yield (37.8 q/ha) from the same crop in Chhotanagpur areas of Bihar.

Higher productivity of dryland forages could be obtained by inter-planting of pearl millet/maize with subabool in 2:1 ratio. The subabool is spaced 1 m apart and cutting height maintained at 50 cm. Under intensive forage cropping system, Dinanath grass + Berseem-Maize + Cowpea yielded about 2000 q/ha of green forage in a year in tarai region of Uttar Pradesh.

In Sub-temperate hilly region of Palampur (H.P.) the best crop rotation was found to be white clover + rye grass giving annual outturn of 1311.0 q/ha of green forage and 259.0 q/ha of dry forage.

Setaria, congo-signal and guinea grass were found to be shade tolerant grasses and could be grown under coconut garden in Kerala under rainfed situation. The productivity of these crops increased with split-application of 40 kg/ha after each cut. Lucerne intercropped in wheat with ratio of 1:2 gave some additional forage yield (50.0 q/ha) and full wheat yield as that of pure wheat crop.

3. Production of Forage Seed

The water management for berseem seed production after the last cut taken for forage
important. The highest seed yield was associated with irrigation water regime maintained at 0.75 IW/CPE. The seed productivity was highest when the last cut was taken for forage by the end of February and thereafter left for seed production. The seed yield drastically reduced if the last cut was delayed beyond February. Application of 100 kg P₂O₅/ha, 50% of the dose applied basally and 50% through foliar helped in obtaining higher seed yield of berseem.

The seed yield of hedge lucerne was significantly improved with spacing of 45 x 30 cm² and with the application of 40 kg P₂O₅/ha. Amongst the different varieties, guinea grass variety Hamil gave higher seed yield under rainfed situation of Kerala.

<table>
<thead>
<tr>
<th>Crop/Variety</th>
<th>Region/Area of Adoption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cowpea</td>
<td></td>
</tr>
<tr>
<td>PC-12, PC-13</td>
<td>Hill</td>
</tr>
<tr>
<td>IFC-8402, UPC-4200, UPC-287</td>
<td>North-East, North-West, South, Central</td>
</tr>
<tr>
<td>Cluster bean</td>
<td></td>
</tr>
<tr>
<td>HFG-119</td>
<td>Chhotanagpur, Central India</td>
</tr>
<tr>
<td>GL-16, GL-18</td>
<td>North-West</td>
</tr>
<tr>
<td>Dinanath grass</td>
<td></td>
</tr>
<tr>
<td>JHP-4, TNDN-1</td>
<td>Hill, North-East</td>
</tr>
<tr>
<td>IGFR-56-1, IGFR-4-2-1</td>
<td>Central</td>
</tr>
<tr>
<td>Maize</td>
<td></td>
</tr>
<tr>
<td>Palampur (Local), J-1018</td>
<td>Hill, South, North-East, North-West, Central</td>
</tr>
<tr>
<td>J-1006, GBM-84-2, Agati-76</td>
<td></td>
</tr>
<tr>
<td>Crops</td>
<td>Varieties</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Sorghum (single cut early maturing)</td>
<td>S-386, S-171, UPFS-21</td>
</tr>
<tr>
<td>Sorghum (single cut, late maturing)</td>
<td>HC-136, UPFS-22, S-194, S-208</td>
</tr>
<tr>
<td>Sorghum (multi-cut)</td>
<td>MFSH-3, MFSH-6, MFSH-7</td>
</tr>
<tr>
<td>Pearl millet</td>
<td>K-84, L-74, Comp.-9, UUJ-IV-M</td>
</tr>
<tr>
<td>Guinea grass</td>
<td>PGG-9, PGG-13, PGG-14, PGG-18</td>
</tr>
<tr>
<td>Lablab purpureus</td>
<td>LP-40-3, JLP-3, JLP-1, JLP-4, LP-40-1, JLP-3, JLP-4</td>
</tr>
<tr>
<td>Rice bean</td>
<td>BC-1, BC-2</td>
</tr>
<tr>
<td>Buffalo grass</td>
<td>IGFRI-3108, CAZRI-1106, FS-391</td>
</tr>
<tr>
<td>Crop</td>
<td>Varieties</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Bird wood grass</td>
<td>CAZRI-76, CAZRI-569</td>
</tr>
<tr>
<td>Berseem</td>
<td>BL-42, HFB-483, BL-2, BL-10, BL-22, UPB-110, Wardan</td>
</tr>
<tr>
<td>Lucerne</td>
<td>Anand-2, LL Comp.3</td>
</tr>
<tr>
<td>Brassica</td>
<td>No. 77, 143</td>
</tr>
<tr>
<td>Oats (single cut)</td>
<td>OS-121, UPO-206, PO-22, OL-125, OL-125, UPO-211, OS-121</td>
</tr>
<tr>
<td>Oats (double cut)</td>
<td>UPC-206, JHO-841, OL-125, UPO-212, PO-3</td>
</tr>
<tr>
<td>Barley (grain and fodder)</td>
<td>K-141, DL-36, DL-454</td>
</tr>
<tr>
<td>Subabool</td>
<td>K-8, S-11, IGFRI 23-1</td>
</tr>
</tbody>
</table>
### Table 40: Varietal identification of different fodder crops for release

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Guinea grass</td>
<td>PGG-9</td>
<td>Hill and North-West</td>
</tr>
<tr>
<td></td>
<td>PGG-14</td>
<td>Central</td>
</tr>
<tr>
<td>2. Dinanath grass</td>
<td>IGFRI 4-2-1</td>
<td>All India basis</td>
</tr>
<tr>
<td>3. Cowpea</td>
<td>UPC-4200</td>
<td>North-East</td>
</tr>
<tr>
<td></td>
<td>UPC-287</td>
<td>All India basis</td>
</tr>
<tr>
<td>4. Cluster bean</td>
<td>HFG-119</td>
<td>North-West</td>
</tr>
<tr>
<td></td>
<td>Guara-80</td>
<td>North-West</td>
</tr>
<tr>
<td>5. Buffel grass</td>
<td>S-3108</td>
<td>All India basis</td>
</tr>
<tr>
<td>6. Oats (multi-cut)</td>
<td>PO-3</td>
<td>Southern hills, North-West and North-East</td>
</tr>
<tr>
<td></td>
<td>UPO-212</td>
<td>All India basis</td>
</tr>
<tr>
<td></td>
<td>(rust resistant)</td>
<td></td>
</tr>
</tbody>
</table>

### ALL INDIA COORDINATED RESEARCH PROJECT FOR DRYLAND AGRICULTURE

1. **Evaluation of various rabi crops under early and normal sowing date under dryland situation**

   (O.P. Singh and K.P. Niranjan)

   Results indicate that gram, sarson and barley are the crops which could be successfully sown at an early as well as normal sowing date. Gram and sarson yielded higher (12.0 q/ha and 4.4 q/ha) at early sowing compared to late sowing. Toria and safflower could not perform well due to disease infestation through germination and initial growth was very good. Lentil yields were higher at late sowing.

2. **Associative studies of pigeonpea based intercropping of fodder crops**

   (K.P. Niranjan and K.S. Gangwar)

   Ten treatments comprising intercropping of pigeonpea with sorghum fodder, teosinte, maize, bajra, sudan grass, *Pennisetum pedicellatum*, cowpea, guar and sunhemp along with with sole pigeonpea were evaluated in randomised block design with three replications. The fodder crops were harvested after 60 days of
sowing. The data revealed that interspace of pigeonpea could be utilised by growing different fodder crops yielding 21 to 168 q/ha green fodder. Among different fodder crops, sunhemp and cowpea proved better recording 168 and 135 q/ha green forage, respectively. However, the yield of grain pigeonpea was reduced by over 68.98 and 43.37% as compared to pure crop of grain pigeon pea (15.95 q/ha) due to intercropping of these forage legumes. Intercropping of *Pennisetum pedicellatum* for forage in grain pigeonpea recorded a forage yield 38 q in addition to 1.0 quintal of seed worth Rs. 2000/- alongwith 10.95 q/ha of base crop -pigeonpea. Thus *Pennisetum pedicellatum* intercropped with pigeonpea appeared to be the most remunerative proposition.

3. Associative studies on sorghum based intercropping of fodder crops

(K.P.Niranjan and K.S.Gangwar)

The treatments combinations consisting of grain sorghum with intercropping of fodder legumes (guar, cowpea, stylo, ricebean, field bean, sesbania, moth, urd and sunhemp) alongwith sole sorghum were laid out in randomised block design with three replications. The fodder crops were harvested after 60 days of sowing. Among different fodder crops, cowpea and sunhemp proved better recording 118 and 109 q/ha green forage respectively. However, the yield of grain sorghum was reduced by over 50% as compared to pure crop of grain sorghum (13.24 q/ha) due to intercropping of these forage legumes. Intercropping of moth for forage in grain sorghum recorded a forage yield 83.00 q/ha alongwith 11.62 q/ha of base crop sorghum. This intercropping system proved the best as it provided 83.00 q/ha nutritious forage without adversely affecting the grain yield of sorghum.

4. Evaluation of cropping systems for dryland areas of Bundelkhand region

(K.P.Niranjan and K.S.Gangwar)

Ten cropping systems involving sorghum (grain) + pigeonpea (2:1), sorghum fodder followed by rabi crops (gram, mustard and lentil), soybean as pure and intercropped with pigeonpea (4:1) and (2:1 ratio) and sunflower followed by rabi crops (gram, mustard and lentil) were evaluated in a randomised block design with three replications. Data on kharif crops have been obtained. Fodder sorghum recorded 99 to 109 q/ha of green fodder in different treatments. Among grain crops, sorghum + pigeonpea (2:1) registered maximum production recording 12.57 q/ha of grain sorghum and 5.77 q/ha of pigeonpea. This was followed by soybean + pigeonpea (2:1) recording 4.77 q/ha of soybean alongwith 7.93 q/ha of pigeonpea. The yields of other kharif grain crops ranged between 6.10 to 8.00 q/ha.

5. Weed control studies in cereal + legumes intercropping system (sorghum + pigeonpea 2:1)

(K.S.Gangwar and K.P.Niranjan)

The experiment with twelve treatments comprising two weedicides (Fluchloralin 0.5 and 1.0 kg/ha and Metalochlor 0.75 and 1.50 kg/ha as pre-emergence) alone and in combination with farmer’s method of weed control, intercultivation and interrow weeding by hand, was laid out in ramdomised block design with three replications. The crop were sown at their optimum seed rates, row spacings and fertilized with 60kg N+ 30kg P₂O₅/ha.

Significantly higher yield of sorghum (12.34 q/ha) and pigeonpea (5.24 q/ha) were obtained with pre-emergence application of Metalochlor 0.75 kg/ha + one intercultivation at 30-35 days stage and Fluchloralin 1.0kg/ha + one intercultivation at 30-35 days stage respectively. Weedy check produced significantly lower yield of sorghum (7.40 q/ha) and pigeon-
pea (3.14 q/ha). Weedicides in combination with intercultivation showed superiority over either weedicides and intercultivation indicating that weedicides or intercultivation were not effective in isolation. Higher doses of both the weedicides were phytotoxic resulting into poor yield of component crops. Weedicides were found to be effective in controlling almost all the weeds except *Celocia urgentia* and *Cyperus rotundus.*

6. Permanent manurial studies in sorghum-gram cropping sequence

(K.S.Gangwar and K.P.Niranjan)

Nine treatments consisting of 100%, and 50% of recommended inorganic fertilizer, FYM and farm residue with and without 50% recommended inorganic fertilizer, farmer’s method, control and 100% inorganic fertilizer with 25 kg ZnSO₄/ha, were tested in R.B.D. with three replications.

The results showed that significantly higher green forage (336.50 q/ha), dry matter (114.36 q/ha) and crude protein (9.43 q/ha) yields were recorded with 100% inorganic fertilizer followed by FYM @ 6 tons/ha+ 50% inorganic fertilizer (301.2 q green fodder, 96.15 q dry matter/ha and 7.44 q/ha crude protein yield). The lowest forage yields (226.90 q/ha green, 65.83 q/ha dry matter and 3.98 q/ha crude protein) were obtained in control treatment. The application of 50% inorganic fertilizer combined with 6 tons FYM/ha indicated 50% saving of chemical fertilizer.

**ALL INDIA COORDINATED RESEARCH PROJECT ON AGROFORESTRY**

1. Collection and evaluation of promising species/cultivars of fuel- fodder and small timber tree/shrub

(R.C.Singh)

Under collection and evaluation of tree components 11 species/cultivars of trees were planted in 3 different spacings during July 1987. Out of 11 spp/cultivars, Leucaena Silvi-4, Leucaena K-8 and Eucalyptus planted in 2 x2 m spacing while Acacia tortilis, A. nilotica, *Prosopis juliflora* and *Dichrostachys nutans* in 3 x 3 m and remaining four viz. *Delbergia sis-soo, H. integrifolia, Albizia lebbek* and *A. amara* were planted in 4 x 4 m spacing. The data pertaining to survival % indicated that the highest survival (98.6%) was recorded in case of *A. tortilis* which is statistically at par with that of *A. amara, A. nilotica, D. nutans* and *P. juliflora* but superior to *D. sissoo, A. lebbek, H. integrifolia, Leucaena S-4 and K-8* (53.3%) after two consecutive planting seasons. Similarly growth data revealed that *P. juliflora* attained maximum height of 184.6 cm which was statistically at par with that of *Leucaena Silvi-4, Eucalyptus, A. nilotica, A. tortilis, A. amara* but superior to remaining ones which were again at par among themselves. The significantly lowest height (53.9 cm) was recorded in case of *A. lebbek.*

None of these species/cultivars differ from each other in terms of collar diameter. However, *Leucaena Silvi-4* produced thicker stem at ground level whereas *A. lebbek* attained the lowest thickness of stem (0.86 cm).

2. Studies on management practices for agroforestry systems

(R.C.Singh)

Under studies on management practices of agroforestry production system component, two varieties of pigeonpea (T21 and T17) were grown as understorey crop of about 14 years old *A. lebbek* plantation (5 x5 m spacing). The four management treatments of tree M₁-tree without any management practice, M₂-tree with 50% lopping, M₃-tree 50 cm deep trench at 50 cm distance from tree base and M₄-tree with 50% lopping + 50 cm deep trench and the pure stand
of both the varieties were grown. It was observed that the combination and trench treatments \((M_3)\), produced significantly higher yield of pea varieties over that treatments where the tree was not managed \((M_0)\). Variety type 21 was found to be better than type 17. Type 21 produced \(0.92\, \text{q/ha}\) grain under managed condition \((M_3)\) which was 33.8% of its own pure cultivation where as T17 could produce only \(0.38\, \text{q/ha}\) grain which was 9.2% of its own pure cultivation (without association of tree).

Another trial comprising same four management practices were imposed on 16-17 year old plantation of \(A.\ tortilis\) planted at \(6 \times 4\, \text{m}\) and \(4 \times 4\, \text{m}\) spacings in 3 replicates. Pigeon pea (Type 21) was grown in association of tree as test crop as well as pure for comparison during July 88.

It was found that the combination of 50% lopping and trench \((M_3)\) produced significantly higher grain yield \(3.14\, \text{q/ha}\) than \(M_0\) (Tree without management). As regards spacing there was no significant difference however wider spacing \((6 \times 4\, \text{m})\) produced slightly higher yield of grain than narrow spacings \((4 \times 4\, \text{m})\). Under \(M_3\) treatment in wider spacing only 59% grain of pure cultivation could be obtained.
The Director General, ICAR laid the foundation stone of a single storey, wooden hut at K.D.Farm in the presence of a galaxy of eminent agricultural scientists from various agricultural universities and state departments of agriculture on 9th July 1988. Dr. Panjab Singh, Director, IGFRI was also present on the occasion. The hut is almost complete. A tractor with farm implements and a jeep were added to the infrastructural facilities.

NRS-1: COLLECTION, EVALUATION, INTRODUCTION AND CONSERVATION OF FORAGE PLANT GERMPLASMS

1.1 Evaluation of some exotic collections of *Medicago* (B.K.Misri)

24 exotic collections of *Medicago* received from NBPGR were sown in May, 1987 and during 1988 plants were fully established. Maximum cumulative fodder yield of 1035.0 q/ha green fodder and 296.21 q/ha dry matter were achieved in EC-190435 followed by EC 190429 (848.0 q/ha green and 258.0 q/ha dry matter yield) and EC 190427 (800.0 q/ha green and 252.0 q/ha dry matter yield).

1.2 Preliminary evaluation of some *Medicago* collections (B.K.Misri)

50 collections of *Medicago* were sown in April, 1988. During first year of establishment, only plant heights and fodder yield were recorded. IL-400 recorded highest green fodder yield (65.0 q/ha) and dry matter (19.5 q/ha). This was followed by IL-263 (64.0 q/ha green and 16.6 q/ha dry fodder), IL 4065 (52.8 q/ha green and 14.7 q/ha dry fodder) and IL 4511 (52.5 q/ha green and 14.7 q/ha dry fodder).

1.3 Primary evaluation of some oat collections (B.K.Misri)

Cultivation of fodder during winter hold a great promise in Kashmir Valley. Of late, cultivation of oat has become very popular and in this connection oat cv. JHO-810 has already been identified as more productive than cv. Kent which is a common cultivar. 32 collections of oat received from IGFRI, Jhansi were evaluated. Highest fodder yield was recorded in JHO-811 (34.5 q/ha green and 10.4 q/ha dry fodder). However, there was lot of variation in all these collections. Collection JHO-811 will be compared with JHO-810.

1.4 Preliminary evaluation of some exotic collections of lupins (B.K.Misri)

Out of 67 collections, two did not germinate, while 12 collections got heavy insect attacks just after their emergence and perished. In rest of the collections, germination was perfect but the subsequent growth got retarded, probably due to unavailability of irrigation. Cytological scoring of the collections has been initiated in collaboration with Kashmir University.

1.5 Collection of fodder plant germplasms (B.K.Misri)
Native germplasms from south-western, Kashmir Himalayas were collected and total of 36 collections of following species were made. These collections have been coded and sown at the K.D. Farm for their evaluation.

<table>
<thead>
<tr>
<th>Species</th>
<th>No. of collections</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Trifolium pratense</td>
<td>3</td>
</tr>
<tr>
<td>2. Medicago sativa</td>
<td>1</td>
</tr>
<tr>
<td>3. Phleum pratense</td>
<td>3</td>
</tr>
<tr>
<td>4. Melica sp.</td>
<td>1</td>
</tr>
<tr>
<td>5. Dactylis glomerata</td>
<td>6</td>
</tr>
<tr>
<td>6. Lolium perenne</td>
<td>4</td>
</tr>
<tr>
<td>7. Agropyron sp.</td>
<td>6</td>
</tr>
<tr>
<td>8. Fastuca rubra</td>
<td>1</td>
</tr>
<tr>
<td>9. Agrostis spp</td>
<td>2</td>
</tr>
<tr>
<td>10. Wheat</td>
<td>2</td>
</tr>
<tr>
<td>11. Maize</td>
<td>2</td>
</tr>
<tr>
<td>12. Chrysopogon echinulatus</td>
<td>2</td>
</tr>
<tr>
<td>13. Lotus corniculatus</td>
<td>1</td>
</tr>
<tr>
<td>14. Lentils</td>
<td>1</td>
</tr>
</tbody>
</table>

1.6 Evaluation of various oat strains for cultivation in *Karewa* lands

(B.K. Misri)

11 strains received from AICRP on fodder crops were compared with oat strain, JHO-81 which has proved to be very productive for the area. Highest fodder yield was achieved in JHO-810 (220.2 q/ha green and 67.8 q/ha dry fodder). The next yielded were RBT-5-206 (107.9 q/ha green and 35.3 q/ha dry fodder) and RBT-505-96 (102.3 q/ha green and 30.6 q/ha dry fodder).

During *rabi* season various combinations of grasses and a legume were sown to establish the suitability of a combination. Oat cv. Kent, berley and wheat were sown as grasses with winter vetch as legume component. Vetch was combined as treatment-I where each line of grass was alternated with vetch while in treatment-II, two lines of vetch were alternated with one line of gram. Results obtained are presented in Table 41.

During *kharif* various combinations of M.P. Chari, maize, teosinte, jowar with cowpeas cv. NP-3 and 450 and guar were sown to find the suitable combination under rainfed conditions. Guar did not germinate at all; in case of M.P. Chari, teosinte, maize and jowar the germination was too erratic. However, in case of cowpeas the germination was about 60 per cent. The best fodder yield of 29.2 q/ha was obtained in case of Cowpeas-450 + maize. It has been established that all these fodder species cannot be cultivated at *karewa* without irrigation. An early sowing during March may help the plants to thrive because of rains during March-May.

2.2 Effect of various spacings and seed rates on seed production in Cowpea cv. NP-3.

(B.K. Misri)

Four seed rates of 15, 20, 25 and 30 kg/ha were combined with four line to line spacings of 20, 30, 40 and 50 cm. The results have been presented in Table 42.

2.3 Effect of various spacings and seed rates on seed production in Oat cv. JHO-810

(B.K. Misri)

Four seed rates of 60, 80, 100 and 120 kg/ha were combined with four line to line spacings of 20, 30, 40, 50 cm. The results have been presented in Table 43.
Table-41. Performance of various grass-legume mixtures

<table>
<thead>
<tr>
<th>Combinations</th>
<th>Fodder Yield (q/ha)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Green</td>
<td>Dry</td>
<td></td>
</tr>
<tr>
<td>1. Kent</td>
<td>84.00</td>
<td>26.30</td>
<td></td>
</tr>
<tr>
<td>2. Kent + Vetch I</td>
<td>127.26</td>
<td>35.77</td>
<td></td>
</tr>
<tr>
<td>3. Kent + Vetch II</td>
<td>72.34</td>
<td>19.65</td>
<td></td>
</tr>
<tr>
<td>4. Barley</td>
<td>78.93</td>
<td>23.90</td>
<td></td>
</tr>
<tr>
<td>5. Barley + Vetch I</td>
<td>142.12</td>
<td>43.41</td>
<td></td>
</tr>
<tr>
<td>6. Barley + Vetch II</td>
<td>87.22</td>
<td>26.60</td>
<td></td>
</tr>
<tr>
<td>7. Wheat</td>
<td>97.12</td>
<td>32.53</td>
<td></td>
</tr>
<tr>
<td>8. Wheat + Vetch I</td>
<td>94.46</td>
<td>27.50</td>
<td></td>
</tr>
<tr>
<td>9. Wheat + Vetch II</td>
<td>88.37</td>
<td>25.45</td>
<td></td>
</tr>
<tr>
<td>10. Vetch</td>
<td>66.66</td>
<td>17.89</td>
<td></td>
</tr>
</tbody>
</table>

Table-42. Effect of various spacings and seed rates on the seed production in Cowpea cv. NP-3

<table>
<thead>
<tr>
<th>Seed rate (kg/ha)</th>
<th>Spacings (cm)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>15</td>
<td>8.94</td>
<td>7.97</td>
</tr>
<tr>
<td>20</td>
<td>7.26</td>
<td>10.45</td>
</tr>
<tr>
<td>25</td>
<td>10.34</td>
<td>9.63</td>
</tr>
<tr>
<td>30</td>
<td>8.02</td>
<td>7.92</td>
</tr>
</tbody>
</table>

Mean: 8.64, 8.99, 9.41, 8.62

C.D.(0.05) Spacing = N.S
Seeds rate=1.09
Spacing x Seed rate=2.19
### Table 43. Effect of various spacings and seed rates on seed production (q/ha) in Oat cv. JHO-810

<table>
<thead>
<tr>
<th>Seed rate (kg/ha)</th>
<th>2.0</th>
<th>3.0</th>
<th>4.0</th>
<th>5.0</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>11.73</td>
<td>13.13</td>
<td>12.56</td>
<td>9.86</td>
<td>11.82</td>
</tr>
<tr>
<td>80</td>
<td>10.23</td>
<td>9.83</td>
<td>10.4</td>
<td>6.94</td>
<td>9.35</td>
</tr>
<tr>
<td>100</td>
<td>11.76</td>
<td>10.46</td>
<td>8.29</td>
<td>5.56</td>
<td>9.01</td>
</tr>
<tr>
<td>120</td>
<td>9.86</td>
<td>13.8</td>
<td>12.8</td>
<td>10.96</td>
<td>11.85</td>
</tr>
<tr>
<td>Mean</td>
<td>10.89</td>
<td>11.80</td>
<td>11.01</td>
<td>8.33</td>
<td></td>
</tr>
</tbody>
</table>

C.D. (0.05) Spacing = 1.87
C.D. (0.05) Seed rate = 1.87
C.D. (0.05) Spacing x seed rate = 5.30
This Centre has vital importance to semi-arid and arid regions of Rajasthan and other parts of the country having similar nature of soil and climate.

Climatic parameters: The highest rainfall was recorded during the month of July and followed by August. The maximum rainfall was recorded in month of September 1988 on 22.9.1988 (111.5mm). The month July and August. The rains received during the month of September were also very good for crops of kharif and rabi. The minimum temperature (4.5°C) was recorded during the month of December and maximum (46.5°C) during the month of May, 1988.

WRS-1: EVALUATION OF FORAGE CROPS

1.1 Evaluation of forage crops and range legumes for higher production

(Fateh Singh and R.K.Jain)

1. Oat (single cut)

The variety REQ-7184 produced green fodder (464.4 q/ha) and dry matter (104.2 q/ha) compared to all the varieties. The variety AKS-4 (377.2 q/ha), JHO-831 (368.3 q/ha) and Kent (365.0 q/ha) were next in green fodder production. But in dry forage production the order was Kent (100.4 q/ha), JHO-831 (97.7 q/ha) and PO-253 (96.3 q/ha) respectively.

2. Oat (multicut)

The variety JHO-842 produced highest green fodder yield (323.3q/ha) but gave lower dry forage yield (72.7 q/ha) as compared to variety UPO-224 (98.4 q/ha) and 225 (79.9 q/ha) in two cuts. The variety next in order yields were UPO-225 (224 (281.2 q/ha).

3. Guar (fodder production)

The result revealed that variety IGFRI-197-1 produced highest green fodder (289.0 q/ha) and dry matter (115.6 q/ha). It was closely followed by the variety IGFRI-8-11. The next varieties in merit were IGFRI-212-1, 579, 859-1, 1019-1, HG-258, IGFRI-1532-1 and 2395-2 respectively. The highest plant height (198.8 cm) was recorded in variety 212-1 It was closely followed by the variety 859-1. The highest number of branches per plant (15.3) were recorded in 197-1 and followed by 859-1. The variety 1539-1 stood first in rank in green and dry forage yield per plant. The variety 212-1 and 859-1 stood 11nd and 111rd in rank in green and dry matter yield per plant respectively.

4. Guar (grain production)

An experiment was laid out to identify high grain producing variety for semi-arid tract of western part of country.

The variety IGFRI -579-1 recorded significantly higher grain yield 16.4 q/ha over all the varieties. The varieties HG-75,IGFRI-119 and 1019-1 were the other high ranking varieties for grain production. However, the variey 2395-1 was found to be lowest grain yielder.

5. Cowpea

An experiment was conducted to study the performance of cowpea varieties. The result revealed that variety IGFRI-450 produced highest green fodder (326.3 q/ha) over all other varieties. The performance of NP-3 (319.3 q/ha) and Russian Giant (315.1 q/ha) were at par with IGFRI-450. However, NP-3 (62.7 q/ha) and
Annual Report 1988

Russian Giant (58.3 q/ha) gave more dry forage yield. The hybrid 8 P 36-54 proved to be low yielder comparing to other cultivars.

6. Clitoria

The results showed that variety ILO 1531-1 produced higher green (103.5 q/ha) and dry matter (35.3 q/ha) over all the varieties. It was closely followed by ILO 1530-1 both in green (97.7 q/ha) and dry matter (33.3 q/ha) yield respectively. The variety ILO-7 gave the lowest green (66.4 q/ha and dry matter) (22.6 q/ha) yield.

7. Moth bean

The variety 51-1 produced highest green fodder (188.9 q/ha) as well as dry matter (44.0 q/ha) yield over all other varieties. However, the variety 87-1 proved to be low yielder. The highest plant height per plant (155 cm), number of branches (15), green fodder (323 gms) and dry forage yield (97.6 gms) were recorded in variety 51-1.

1.2 Effect of fertilizer application on fodder yield of Cenchrus ciliaris

An experiment was conducted to study the nitrogen and phosphorus on the fodder yield of Cenchrus ciliaris under rainfed conditions.

The 60 kg & 90 kg nitrogen produced significantly higher forage yield over no nitrogen. No significant difference amongst the levels of phosphorus was observed in the experiment. However, the increasing trend was recorded upto 40 kg P<sub>2</sub>O<sub>5</sub> per hectare. The yield at N60 P40 was 2.7 q/ha and N90 P40 29.2 q/ha green fodder as against N<sub>0</sub>P<sub>0</sub> (14.4 q/ha).

WRS 2: STUDIES ON AGRO-HORTO-SILVO-PASTORAL SYSTEMS

2.1 The effect of trees on the yield of grasses and vice-versa

(Fateh Singh and R.K. Jain)

An experiment was conducted to study the effect of different trees on the yield of grass and vice-versa. The experiment consisted of four tree components viz., Ailanthus exelsa, Acacia nilotica, Prosopis cineraria and Albizia lebbeck and three grass components viz., Panicum antidotale, Cenchrus and Cenchrus setigerus.

On an average the maximum survival percentage was recorded in Acacia nilotica and Prosopis cineraria (87.5%). It was closely followed by Albizia lebbeck (85.23). Minimum survival percentage was recorded in Ailanthus exelsa (58.2%). The complementary effect of grasses was noticed on the establishment of saplings, height of trees and collar diameter. Maximum height (79 cm) was recorded in Acacia nilotica. It was closely followed by Albizia lebbeck. Minimum height was noticed in Ailanthus exelsa (39.7 cm). On an average maximum collar diameter was recorded in Albizia lebbeck. It was closely followed by Ailanthus exelsa. The minimum collar diameter was recorded in Acacia nilotica and Prosopis cineraria.

Amongst the grasses the performance of Cenchrus ciliaris was better which produced maximum biomass (17.8 q/ha).

2.2 Alley cropping studies with Albizia lebbeck and A. amara.

(Fateh Singh and R.K. Jain)

The cowpea NP-3 produced highest forage yield (170.5 q/ha with A. lebbeck and 169.4 q/ha with A. amara) over all the crops sown in the experiment. The next crops in merit were cowpea HFC 42-1 and guar IGFRI-212 respectively. The establishment percentage was higher in Albizia amara as compare to Albizia lebbeck. The growth of Albizia amara was faster as compare to Albizia lebbeck. In general the growth of A. lebbeck is faster than A. amara. The growth of trees were not effected by the fodder crops.

2.3: Effect of different spacings on the yield of grasses and Acacia nilotica
The yield of grasses were not affected by *Acacia* and the grasses also not affected the establishment height and width of tree. *Cenchrus ciliaris* produced more biomass as compare to *Panicum antidotale*. On an average 86% establishment of trees was recorded. The height of trees varied from 98 cm to 117 cm and collar diameter from 3.7 to 4.6 cm.

**WRS-3: STUDIES ON NEMATODES IN RELATION TO FORAGE CROPS**

(R.K. Jain)

1. General survey

1. A general survey of the farm revealed that during the months of September-November almost 100% leaves (pinnae) of *Albizia lebbeck* plants were infested with rust pustules of *Ravennalia* spp. The heavy infection caused premature drying and defoliation of leaves and were unpalatable to sheep. Pod shells were also heavily infested.

Heavy powdery mildew infection was recorded on *Delbergia sissoo* leaves.

*Cercospora* leaf spots were recorded on *A. lebbeck* and *A. excelsa*.

Insect galls were observed on *P. cineraria*. Root-knot nematode was recorded in nursery beds.

2. Reaction of root-knot nematode, *Meloidogyne* to differential hosts

Two populations of root-knot nematode from nursery beds were tested using International host differentials for species identification (Table 44).

<table>
<thead>
<tr>
<th>Hosts</th>
<th>Tobacco</th>
<th>Cotton</th>
<th>Pepper</th>
<th>Watermelon</th>
<th>Peanut</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety</td>
<td>NC-95</td>
<td>Delapine</td>
<td>California wonder</td>
<td>Charleston gray</td>
<td>Florunner</td>
</tr>
<tr>
<td>Reaction</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

The reaction showed that only one specie of root-knot nematode, *Meloidogyne incognita* is prevalent in the light sandy soils of Avikanagar, which produces large galls.

3. 82 soil/root samples collected from mainly Avikanagar, Jodhpur and Jaisalmer revealed the prevalence of *Helicotylenchus* spp. in almost all the samples collected from grass and legumes species. Tree species were mostly free from nematodes. In all, six nematode genera were indentified (Table 45).

4. Endomycorrhizal VAM fungi could be exploited for their beneficial use in the management of pastures with low levels of phosphorus inputs.

5. Weed flora of farm: 32 weed flora were indentified belonging to 18 families (Table 46.)

Table 45: Incidence and frequency of occurrence of Nematodes associated with forage/pasture species in semi-arid/arid parts of Rajasthan.

<table>
<thead>
<tr>
<th>Species</th>
<th>Location</th>
<th>No. of samples</th>
<th>Hel</th>
<th>Hop</th>
<th>Tyl</th>
<th>Ty</th>
<th>Pr</th>
<th>Me</th>
<th>Sap</th>
<th>Misc</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grasses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Chenopodium ciliaris</td>
<td>Avikanagar</td>
<td>12</td>
<td>12</td>
<td>3</td>
<td>2</td>
<td>-</td>
<td>2</td>
<td>12</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>2. C. ciliaris</td>
<td>Godhpur</td>
<td>6</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>6</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>3. C. scutigerus</td>
<td>Avikanagar</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>4. Lasturia sindicus</td>
<td>Chandan</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>5. L. sindicus</td>
<td>Pokharan</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td></td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>6. L. scutigerus</td>
<td>Jaipur</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td></td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>7. Aristida funiculata</td>
<td>Jaipur</td>
<td>2</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td></td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>8. Pennisetum typhoides</td>
<td>Avikanagar</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>9. P. hybridus</td>
<td>Avikanagar</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10. Macroptilium arospurpureum</td>
<td>Avikanagar</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>11. Stylosanthes hamata</td>
<td>Avikanagar</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>12. Vigna aconitifolia</td>
<td>Avikanagar</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td></td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>13. V. unguiculata</td>
<td>Avikanagar</td>
<td>6</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>14. Cyamopsis tetragonoloba</td>
<td>Avikanagar</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td></td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Fodder trees</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Acacia nilotica</td>
<td>Jodhpur</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Prosopis cineraria</td>
<td>Jodhpur</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>3</td>
<td></td>
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</tr>
<tr>
<td>17. P. cineraria</td>
<td>Avikanagar</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Zizyphus nummularia</td>
<td>Jodhpur</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>19. Z. nummularia</td>
<td>Avikanagar</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>20. Salvadoria Cieoides</td>
<td>Jaipur</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. Teckomella undulata</td>
<td>Jaipur</td>
<td>1</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. Dichrostachys nuda</td>
<td>Avikanagar</td>
<td>4</td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. Allanthes excelsa</td>
<td>Avikanagar</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Hel</th>
<th>Hop</th>
<th>Tyl</th>
<th>Ty</th>
<th>Pr</th>
<th>Me</th>
<th>Sap</th>
<th>Misc</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>82</td>
<td>48</td>
<td>20</td>
<td>20</td>
<td>7</td>
<td>10</td>
<td>2</td>
<td>82</td>
<td>48</td>
</tr>
<tr>
<td>Percentage frequency</td>
<td>48</td>
<td>24</td>
<td>24</td>
<td>8</td>
<td>12</td>
<td>2</td>
<td>100</td>
<td>58</td>
<td></td>
</tr>
</tbody>
</table>

Hel = Helicotylenchus spp.; Hop = Hoplolaimus spp.; Tyl = Tylenchorkynchus spp.; Ty = Tylenchulus spp.; Pr = Pratylenchus spp.; Me = Meloidogyne spp.; Sap = Saprophytes; Misc = Miscellaneous (unidentified)
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Botanical Name</th>
<th>Family</th>
<th>Common name</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Aerva tomentosa</td>
<td>Amaranthaceae</td>
<td>Bhuari</td>
<td>Abundant</td>
</tr>
<tr>
<td>2.</td>
<td>Celosia argentea</td>
<td>Amaranthaceae</td>
<td>-</td>
<td>Abundant</td>
</tr>
<tr>
<td>3.</td>
<td>Borreria articulata</td>
<td>Rubiaceae</td>
<td>Agio</td>
<td>Scanty</td>
</tr>
<tr>
<td>4.</td>
<td>Phyllanthus maderaspatensis</td>
<td>Euphorbiaceae</td>
<td>Khajerio khad</td>
<td>Rare</td>
</tr>
<tr>
<td>5.</td>
<td>Cocculus pendulus</td>
<td>Manispermaceae</td>
<td>Bajarbel/pilwani</td>
<td>Abundant</td>
</tr>
<tr>
<td>6.</td>
<td>Polycarpea corymbosa</td>
<td>Caryophyllaceae</td>
<td>Zunio khad</td>
<td>Abundant</td>
</tr>
<tr>
<td>7.</td>
<td>Acantho spermùshispidum</td>
<td>Asteraceae</td>
<td>Baru</td>
<td>Abundant</td>
</tr>
<tr>
<td>8.</td>
<td>Sorghum halepense</td>
<td>Poaceae</td>
<td>-</td>
<td>Common</td>
</tr>
<tr>
<td>9.</td>
<td>Eragrostis tenuifolia</td>
<td>Poaceae</td>
<td>-</td>
<td>Common</td>
</tr>
<tr>
<td>10.</td>
<td>Aristida descensus</td>
<td>Poaceae</td>
<td>Rampalal/Lamp</td>
<td>Abundant</td>
</tr>
<tr>
<td>11.</td>
<td>Heliotropium maritimum</td>
<td>Boraginaceae</td>
<td>Chou santari</td>
<td>Common</td>
</tr>
<tr>
<td>12.</td>
<td>H. subulatum</td>
<td>Boraginaceae</td>
<td>Kali bui</td>
<td>Scanty</td>
</tr>
<tr>
<td>13.</td>
<td>Siericostoma pauciflorum</td>
<td>Boraginaceae</td>
<td>-</td>
<td>Scanty</td>
</tr>
<tr>
<td>14.</td>
<td>Vernonon cinerea</td>
<td>Asteraceae</td>
<td>-</td>
<td>Rare</td>
</tr>
<tr>
<td>15.</td>
<td>Amberboa recemosa</td>
<td>Asteraceae</td>
<td>-</td>
<td>Rare</td>
</tr>
<tr>
<td>16.</td>
<td>Pulicaria angustifolia</td>
<td>Asteraceae</td>
<td>-</td>
<td>Rare</td>
</tr>
<tr>
<td>17.</td>
<td>Sida cordifolia</td>
<td>Malvaceae</td>
<td>Bal</td>
<td>Scanty</td>
</tr>
<tr>
<td>18.</td>
<td>Crotonia buria</td>
<td>Fabaceae</td>
<td>-</td>
<td>Abundant</td>
</tr>
<tr>
<td>19.</td>
<td>Tephrosia purpurea</td>
<td>Fabaceae</td>
<td>-</td>
<td>Common</td>
</tr>
<tr>
<td>20.</td>
<td>T. hemilonti</td>
<td>Fabaceae</td>
<td>Biyani</td>
<td>Scanty</td>
</tr>
<tr>
<td>21.</td>
<td>Convolvulus macrophyllus</td>
<td>Convolvulaceae</td>
<td>Santari</td>
<td>Scanty</td>
</tr>
<tr>
<td>22.</td>
<td>Blasania gracini</td>
<td>Cucurbiteae</td>
<td>-</td>
<td>Rare</td>
</tr>
<tr>
<td>23.</td>
<td>Momordica charantia</td>
<td>Cucurbiteae</td>
<td>Jangli Kerala</td>
<td>Scanty</td>
</tr>
<tr>
<td>24.</td>
<td>Commelina forskali</td>
<td>Commelinaceae</td>
<td>Bakhana</td>
<td>Common</td>
</tr>
<tr>
<td>25.</td>
<td>C. beqgaleulis</td>
<td>Commelinaceae</td>
<td>-</td>
<td>Common</td>
</tr>
<tr>
<td>26.</td>
<td>Leucos aspera</td>
<td>Lamiaceae</td>
<td>Gomo</td>
<td>Common</td>
</tr>
<tr>
<td>27.</td>
<td>Tribulus terrestris</td>
<td>Zygophyllaceae</td>
<td>Gokru</td>
<td>Common</td>
</tr>
<tr>
<td>28.</td>
<td>Amaranthes spp.</td>
<td>Amaranthaceae</td>
<td>Cholai</td>
<td>Abundant</td>
</tr>
<tr>
<td>29.</td>
<td>Launaea procumbens</td>
<td>Compositae</td>
<td>Jangligobi</td>
<td>Abundant</td>
</tr>
<tr>
<td>30.</td>
<td>Indigofera cordifolia</td>
<td>Papilionaceae</td>
<td>Bekaria</td>
<td>Scanty</td>
</tr>
<tr>
<td>31.</td>
<td>Boorhaavia hispida</td>
<td>Nictaginaceae</td>
<td>-</td>
<td>Scanty</td>
</tr>
</tbody>
</table>
SRS-1: COLLECTION, INTRODUCTION AND EVALUATION OF GERMPLASM OF RANGELAND SPECIES

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

1.1 Evaluation of *Cenchrus ciliaris* population for dry tracts

Plant habit varied among the population, ranging from prostrate (S-262), to semi erect (Jodhpur local, S-303, S-358, Agra local, IGFRI-3133, S-214, IGFRI Reg. Station 16, IGFRI Reg. Station 14, and to erect (S-357, IGFRI-59-1, IGFRI-3108, IGFRI Reg. Station-17). A wide range of variation was observed for plant height (72.3 cm as in S-262 to 149.0 cm as in IGFRI-3132), tiller number (17.6 as in IGFRI Reg. Station 17 to 34.6 as in S-214), basal diameter (5.8 as in S-357 to 11.8 as in IGFRI-3132) among the populations of the grass species studied. The green fodder yield varied from 7.3 to 46.5 q/ha, the highest being recorded by Pusa Giant which was followed by IGFRI-3132, Molopo. Green forage yield of the population S-262 was lowest among the lines of the grass species studied.

1.2 Evaluation of promising genera of grasses for *Sehima Dichanthium* grass cover

Eighteen genera of promising range grasses (*Cenchrus ciliaris* IGFRI-3108, *Cenchrus* hybrid, *Panicum maximum*, *Panicum antidotale*, *Pennisetum polystachyon*, *Chrysopogon fulvus* cv. Mhow, *Chrysopogon fulvus* cv. Chandigarh, *Dichanthium annulatum*, *Dichanthium caricosum*, *Pennisetum flacidum*, *Paspalum dilatatum*, *Paspalum notatum*, *Digitaria*, *sphacelata*, *Digitaria decumbens*, *Eragrostis superba*, *Eragrostis curvola*, *Setaria sphacelata* and *Amphilobis glabra* were evaluated. On the basis of green fodder (harvested once in season), *Panicum maximum* (208.3 q/ha) followed by *Pennisetum polystachyon* (208.0 q/ha) recorded highest yield while *Paspalum notatum* and *P. dilatatum* yielded lowest, being 7.8 and 5.4 q/ha respectively.

1.3 Evaluation of *Stylosanthes hamata* populations for dry tracts

Eleven populations of *Stylosanthes hamata* obtained from Agriculture Research Centre, Fort Pierce, Florida, along with check *Stylosanthes hamata* cv. Verano were evaluated.

Out of the populations, five were erect (EC 168634, 168433, 168641, 168640, 168635), six semierect (EC 168629, Verano, 168630, 168639, 168638, 168628 ) and prostrate narrow leaved (EC 168631) type. Early growth of these populations was slow but growth picked up during August/September. Two of the populations (EC 168634 and 168635) showed continued vegetative growth during winter months.

A wide range of variability was recorded in plant height (30.0 to 68.8 cm), number of main branches (4.3 to 6.5) per plant and flowering period (66 to 110 days). Early flowering was recorded in population (EC 168638) while populations (EC 168634 and 168635) were late flowering variants.

Population EC 168631 was the highest yielder for green fodder (51.1 q/ha) followed by *Stylosanthes hamata* cv. Verano (45.8 q/ha) as against 43.1 q/ha and 33.0 q/ha given by EC 168639 and EC 168640 respectively. Of the 11 populations studied, only EC 168631, a prostrate growth form produced higher yield than the check i.e. *S. hamata* cv. Verano, while remaining collections were inferior over control.
1.4 Evaluation of promising genera of range legumes for *Sehima Dichanthium* grass cover

A trial involving twelve legumes including *Stylosanthes hamata* cv. Verano, *Stylosanthes hamata* (tetraploid), *Stylosanthes humilis*, *Stylosanthes scabra*, *Stylosanthes viscosa* *Stylosanthes guianensis*, *Clitoria ternatia*, *Macroptelium atropurpureum*, *Macroptelium lathyroides*, *Desmodium tortuosum* *Desmanthus vergatus* and *Atylosia scarabaeoides* was laid out. *Macroptelium lathyroides* was the highest yielder for green fodder (90.0 q/ha) followed by *Macroptelium atropurpureum* (65.4 q/ha) while legumes *Atylosia scarabaeoides* and *Stylosanthes viscosa* recorded lowest yields.

1.5 Evaluation of *Leucaena leucocephala* lines for *Sehima Dichanthium*

Seedlings of six introductions of *Leucaena leucocephala* (1) Cunningham, (2) Peru, (3) K-8, (4) K-28, (5) K-67 and (6) IGFRI-23-1 were raised and planted during June 1988. By August 1988 the incidence of psyllid bugs on tender seedlings had adverse effect and hence no data on growth and production could be recorded. However, seedlings of the lines recovered from the attack to produce new sprouts by December.

SRS-2: STUDIES ON SILVIPASTORAL PRACTICES FOR DEGRADED RED GRAVELLY SOILS OTHERWISE DOMINATED BY *HETEROPOGON GRASSLANDS FOR IMPROVED PRODUCTION*

(P.K.Jayan and M.S.Žaut)

The studies initiated during 1987 continued for the second year. Among the various silvipastoral systems tested, highest production was recorded in *Leucaena leucocephala/Panicum maximum* combination registering an yield of 720.6 q/ha. Among the various combinations tested, lowest yield was recorded in the leucaena intercropped with grass *Chloris gayana*. Poor regeneration of tussocks of *Chloris gayana* in treatments, involving the grass, was noticed.

In the 2nd series, highest production was recorded in the combination wherein leucaena was intercropped with grass *Chrysopogon fulvus* yielding 782.4 q/green/ha. Next highest production was obtained in the combination of the said grass with legume *Stylosanthes hamata* followed by *Cenchrus ciliaris*, *S. hamata* combination yielding 718.2 and 700.8 q green/ha respectively.

In the 3rd set of the said experiment, range grass *Dichanthium annulatum* was found adversely affected when grown in combination with legume *Macroptilium atropurpureum*. The grass was completely smothered by the legume thereby registering a poor yield of 22.0 q/ha. Here also highest yield was recorded in the combination of *Leucaena/Chrysopogon fulvus* registering an yield of 623.5 q green/ha. Herbage yield was lowest in *Leucaena/Dichanthium annulatum* combinations yielding 519.2 q green/ha.

Untreated control plots of *Leucaena leucocephala* yielded 265.6 q green/ha, wherein the contribution from fuelwood and fodder portion to total yield were to the tune of 117.9 q green/ha and 147.8 q green/ha respectively.

On similar lines, *Leucaena leucocephala* plantings of 1.5 x 1.5 m spacing were intercropped with grass *Cenchrus ciliaris* alone or in combination with legumes *Stylosanthes scabra*, *Stylosanthes viscosa*, *Stylosanthes guianensis*, *Phaseolus lathyroides* and *Atylosia scarabaeoides*. Pure intercrops of the respective legumes were also laid out along with, for comparison during July/August, 1988.
SRS 3: EVALUATION OF CULTIVATED FODDER CROPS AND THEIR VARIETIES

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

3.1 Evaluation of cowpea varieties for fodder production

Nine cowpea varieties viz., IL-143, IL-450, IL-515, IL-1008, IL-984, IL-978, Russian giant, HFC 42-1 and NP-3 were evaluated.

Green fodder production of varieties varied from 239.0 to 389.0 q/ha within 86-96 days duration. The highest green fodder production was recorded with IL-143 (389.0 q/ha) followed by IL-450 (343.0 q/ha) and IL-515 (322.0 q/ha). Performance of these varieties was comparable to Russian giant (315.0 q/ha). Lowest fodder yield was recorded in NP-3. IL 450 had maximum number of leaves/plant (28) succeeded by Russian giant (20 leaves/plant) and IL-143 (17.7 leaves/plant). Rest of varieties borne 10-15 leaves/plant. All varieties except NP-3 were trailing type, IL984 was tallest followed by IL 515 and IL 1008.

3.2 Evaluation of sorghum varieties for fodder production

An experiment consisting of 10 varieties of sorghum was conducted during kharif. Fodder production of varieties under study varied significantly. S-136 produced the highest green fodder (518.5 q/ha) followed by D 11-1-1 (504.6 q/ha); D 23-2-1 (437.5 q/ha) and J-set-3 (437.5 q/ha). These varieties remaining at par with each other were significantly superior to PC-6 (324.0 q/ha), SSG-59 (326.4 q/ha) and Byawara (289.3 q/ha). S 136 and D 11-1-1 gave 10.5 and 15.3 per cent more green fodder than local check J-set-3, respectively. J-set-3 and D 23-2-1 being at par were significantly taller than S136, SSG-59 and Vidisha. Plant height of varieties under study ranged from 276.2 cm with Vidisha to 348.0 cm with J-set-3. Greater leaf size of S-136 may be possible reason for its highest fodder production.

3.3 Performance of napier- bajra hybrids

Twelve varieties of napier-bajra hybrid consisting of 5 IGFRI lines (BN 86089, BN 82048, BN 86061, BN 86073 and IGFRI-3), 4 UAS Dharwad collections (CBH-8, BH-12, NB4, NB5) along with NB 21, Co-1, and Kamadhenu were evaluated.

Green fodder yields of napier-bajra hybrid varieties varied from 134.3 q/ha with BN-86048 to 395.0 q/ha with NB-5. Differences in fodder production was statistically significant. NB-4, NB-5, NB-21, BH-8, BN-86073 and BN-86061 remaining at par with each other were significantly superior to Co-1, Kamadhenu and BH-12. The highest fodder yield was recorded with NB-5 (395.0 q/ha). The highest fodder yield was recorded with NB-5 (395.0 q/ha) followed by NB-21 (385.7 q/ha) and BN-86073 (384.3 q/ha). None of IGFRI collections were superior to NB-21. However, they were found better than Co-1 (265.4 q/ha) and Kamadhenu (250.0 q/ha) expecting BN 86048.

NB-21, recording plant height of 453.6 cm was the tallest followed by BN-86073 (428.1 cm plant height) and NB-4 (422.1 cm plant height). IGFRI-3 had maximum number of tillers/tussock (15.0) followed by NB-5 (13.4), BN-86089 (13.3) and BH-12 (12.9). Less number of tillers per plant was noticed in Co-1 (7.3), NB-21 (8.0) and Kamadhenu (9.4).

IGFRI-3, BH-12 and Kamadhenu recording >1.0 leaf stem ratio was more leafy as compared to other varieties.

3.4 Evaluation of oats varieties

Green fodder production potential varied from 210.6 to 295.9 q/ha. Kent producing 295. q/ha topped list followed by JHO 825 (262.6 q/ha) and JHO-822 (243.0 q/ha). However, differences in
green fodder production of Kent, JHO 825, JHO 822 was statistically not significant. Kent was significantly superior to JHO 829 (232.3 q/ha), JHO 817 (227.9 q/ha) and JHO 826 (210.6 q/ha). Performance of all IGFRI oats was at par with each other.

As regards dry matter yield, JHO-825 producing the highest (64.3 q/ha) was significantly superior to JHO 817 (52.4 q/ha) and JHO 826 (56.4 q/ha) was at par with each other. JHO-825 had maximum height (129.4 cm) followed by JHO 817 (126.7 cm) and JHO 822 (125.4 cm). JHO-826, recorded lowest plant height (110.1 cm). Maximum length (36.6 cm) and breadth (1.94 cm) of 3rd leaf from top was recorded in JHO-825.

In terms of dry matter productivity per hectare per day, JHO-825 produced the maximum (79.0 kg/ha/day) followed by JHO-829 (68.1 kg/ha/day) and JHO 822 (65.5 kg/ha/day).

Seed production potential of varieties under test ranged from 20.0 q/ha with Kent to 38.2 q/ha with JHO-822. Difference in seed yields of different varieties was significant. JHO-822, JHO-826 and JHO-829 producing 38.2, 37.5 and 36.9 q/ha of seed respectively, remained at par with each other but produced significantly more seed than Kent (20.1 q/ha) and JHO 817 (25.2 q/ha). Seed yield of JHO-825 was 33.9 q/ha. Harvest index was more in JHO-825 (30.1%) followed by JHO-829 (28.2%) and JHO-826 (25.7%). Kent and JHO-817 had harvest index values of 18.4 and 16.8 per cent respectively.

3.5 Evaluation of varieties of barley for fodder cum-seed production

Eight varieties of barley viz. EB-7325, DL-36, DL-454, DL-157, DL-417, K-141, Azad and Ratna were tested to find out their potential as fodder-food production.

Plant height, number of earheads/metre row length, number of seeds/earhead and seed yield were drastically reduced by 17.6, 54.6, 24.6 and 89.3 per cent, respectively, under barley for fodder food system over uncut one. Green fodder production of varieties under test varied from 50.0 to 116.6 q/ha. Ratna, K141, Azad and DL-157 (100-116.6 q/ha of green fodder) remaining at par were significantly better than DL-417, EB-7325 and DL-454. Seed yields after ratooning for fodder were varied from 1.05 -2.50 q/ha; the highest being recorded with Azad (2.5 q/ha) followed by DL-454 (2.29 q/ha), K-141 (2.19q/ha), DL-417 (1.87 q/ha) and Ratna (1.78 q/ha).

Under barley for seed production, only (uncut), K-141 recording 21.3 q/ha of seed yield was the highest yield and significantly superior than rest of varieties except Azad (19.0 q/ha). The lowest seed yield was recorded with EB-7325 (9.5 q/ha). Ratna producing 17.3 q/ha of seed ranked 5th the list.

On the basis of gross income computed on price basis of Rs. 180/q for seed and Rs. 50/q for green fodder, all varieties of barley under test recorded more gross return (Rs. 2837-6224) under fodder-food system as compared to their cultivation for seed only (Rs. 1706-3843). The profitability of fodder-food crop over solely food crop was maximum with variety Ratna (Rs. 3039) followed by K-141 (Rs. 2394), DL-157(Rs. 2187) and Azad (Rs. 2025). In other varieties such variation was Rs. 295/ha with DL-417 to Rs. 1276/ha with DL-36.

SRS- 4: CROPPING SYSTEMS

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

4.1 Studies on nitrogen requirement of cenchrus grown in association with stylos and siratro

Sole cenchrus produced 984.0 kg/ha of green
fodder whereas, its fodder production in association with legumes varied from 523.0 kg/ha with S. scabra to 605.0 kg/ha with siratro. Thus, recorded reduction in cenchrus yields due to legume association by 34 to 46 per cent over pure cenchrus + legumes except cenchrus + S. scabra which was lower than pure cenchrus. Sole S. hamata outyielded all legumes as well as all intercropping treatments by producing 1331 kg/ha green fodder. On the basis of LER values, all cenchrus + legume mixture had more than LER values (1.32 - 1.38).

Beneficial effect of legumes on cenchrus in terms of fodder production was not observed. However, in terms of total fodder production from cenchrus + legumes at zero fertilizer level, yields of cenchrus + siratro and cenchrus + S. hamata were equivalent to the pure cenchrus yields with 20-40 kg N/ha. Boost in fodder production of cenchrus and cenchrus + legumes was greater at 60 kg N/ha than 20 and 40 kg N/ha when compared with the control.

4.2 Screening of legumes for intercropping with Panicum maximum

In intercropping with panicum, performances of siratro, S. hamata and P. lytheroides were better than S. guianensis and S. scabra. Legume association led to 22 - 36.4 per cent reduction in fodder production of panicum but total fodder production under panicum + legume was more than pure panicum + P. lytheroides gave maximum green and dry fodder (48.9 q/ha and 21.4 q/ha respectively) followed by panicum + siratro (45.8 q/ha green and 21.0 q/ha dry fodder) and panicum + S. hamata (45.8 q/ha green and 19.0 q/ha dry fodder). Fodder yield of pure panicum was 44.0 q/ha (green) and 19.0 q/ha (dry). Lowest green and dry fodder yields were recorded with panicum + S. scabra (31.1 q/ha green and 14.8 q/ha dry).

SRS-5: CULTURAL MANAGEMENT

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

5.1 Response of Cenchrus varieties to different levels of nitrogen

Differences in fodder production of different varieties was not significant. However, variety 214 produced maximum (341.0 kg/ha) followed by S-3108 (313.0 kg/ha) and S-59-1 (284 kg/ha). Similar trend was noticed in dry matter yields. Variety 214 had low plant height of 92.4 cm compared to S-3108 (122.8 cm) and S-59-1 (123.8 cm), but had maximum number of tillers/tussock (23.7) and leaves/tussock (424) than S-3108 (18.7 tillers and 203 leaves/tussock) and S59-1 (18.2 tillers/tussock and 234 leaves/tussock).

Green and dry matter yields were significantly increased due to increasing levels of nitrogen up to 60 kg N/ha. N application favourably increased plant height, tiller/tussock and leaves/tussock. Magnitude of increase in green fodder production due to 30,60 and 90 kg N/ha was 48.0 135.8 and 137 per cent over the control, respectively.

5.2 Response of Bracharia to different levels of nitrogen and row spacing

Being an establishment season, the yield of Bracharia was quite low. Closer row-to-row spacing was better (38.3 q/ha ) green fodder than wider row-to-row spacing (287.0 q/ha). In general, response to applied nitrogen was quite low. However, at 60 cm row to row spacing, response up to 60 kg N/ha was noticed. The magnitude of response due to 30 and 60 kg N/ha over the control was 36.6 and 41.6 per cent respectively in 60 cm row-to-row spacing. However, such response was not noticed at 90 cm row-to-row spacing.
THIRD INTERNATIONAL RANGELAND CONGRESS

The 5-day Third International Rangeland Congress was organised at New Delhi from November 7-11, 1988. The Congress was inaugurated by Hon'ble Shri R. Venkataraman, President of India on 7th November at Vigyan Bhavan. In the congress more than 396 delegates from India and 40 other countries all over the world participated and presented the papers. Eleven Symposia on different aspects of research and managements of Rangelands were held during these days. Brief Symposiumwise recommendations are presented below:

RANGE RESOURCE INVENTORY AND MONITORING

The range classes and categories of each area and country must be properly defined. Evaluation of productive potential and susceptibility to damage must be undertaken. Range research must now go from basic analysis of variables to ask research questions that generate answers which can be applied. Different remote sensing techniques are potential tools for the inventory of the rangeland resources.

PRIMARY PRODUCTIVITY AND CARRYING CAPACITY OF RANGELAND ECOSYSTEMS

Manage rangelands to optimize rather than maximize productivity. Introduction of exotic species with higher productivities should be closely examined because short-term higher productivities may not be sustainable in the long term. Promote nitrogen-fixing legumes which increase carrying capacity in nitrogen limited especially burned, rangelands.

DYNAMICS AND SYSTEMS ANALYSIS OF RANGELANDS

Long-term rangeland studies based on holistic, total system approach should be promoted in different bio-climatic regions. Efforts should be made to generate rangeland ecosystem modelling capability for prediction of productivity, rangeland condition and carrying capacity, etc. For this purpose appropriate training and exchange programmes should be devised, particularly for the researchers from developing countries, to generate necessary technical infrastructure. Mechanisms should be found to ensure continued interaction between modellers and range scientists in long term studies from its very beginning.

SUCCESSION IN RANGE ECOSYSTEM DIVERSITY, DOMINANCE AND PRODUCTION

Reduction and sometimes even total ban on grazing of livestock, deferred and rotational grazing have therefore, been recommended as measures urgently needed to rehabilitate the rangelands in sensitive areas. Diversity generates stability. Therefore, the impact of the different biotic, abiotic factors seems to be different in different situations. Hence, a synthetic multidimensional and integrated approach involving computer application on the basic data generated by different investigation at various levels need to be urgently undertaken.

PHYSIOLOGICAL PROCESSES, WATER RELATIONS & RANGE PRODUCTION

Study of the interactive effects of tree components on ground flora (particularly of range grasses) should be undertaken with special emphasis on growth and use of water and nutrient by both the components. Physiological studies should be undertaken to tailor appropriate utilization pattern of range grasses of arid and semi-arid regions for obtaining sustained productivity with efficient use of water and nutrients without sacrificing quality of the forage. In this context grass legumes mixture systems should receive attention. Emphasis is warranted on the study of the combined role of growth

...
regulators and nutrients for synchronization of flowering and to promote seed setting ability with higher seed production in the range legumes.

GENETIC IMPROVEMENT OF RANGE SPECIES

Every effort should be made to collect, conserve and evaluate germplasm of grasses, legumes and fodder-cum-fuel trees, particularly from remote areas, where still considerable variability exists. Natural variability by growing elite plants in isolation for cross pollination must be exploited to improve the productivity of the cultivars. Species rich areas need to be protected. Utilization of native rangeland species may be given priority.

In view of the importance of the grasses, legumes, shrubs and trees in range improvement, there is need to undertake intensive breeding programmes for desirable attributes and also breeding for stress conditions like drought, cold, acidic and alkaline situations etc. in order to develop resistant varieties.

MANAGEMENT OF GRAZING RESOURCES

Necessity of coalition of scientists, educators, economists, the news media and particularly the national policy makers was emphasised to solve current environmental problems worldwide in order to preserve the global ecosystems in future. Determination of carrying capacity of site, specified technology and enactment of grazing management rules in accordance to the carrying capacities was recommended. It was also emphasized that none of these steps are going to be successful unless education in range management is introduced at all levels, so that both managers and husbandrymen are aware of carrying capacities.

SECONDARY PRODUCERS-RANGE RESOURCE INTERACTION, ANIMAL HEALTH AND EFFICIENCY

Rangeland productivity be expressed in terms of primary production as well as animal production based on long term grazing trials. In addition to the quantity, the quality of biomass is important from animal production point of view. The protein content in tropical range pasture decreases after the monsoon season. Perennial legumes should be introduced to maintain the protein level in the herbage. In the absence of legumes, protein supplementation be provided to grazing animals during dry season to ensure 7% protein in diet for maintenance and 12% protein for growth and production. Conservation of herbage from rangeland, when available in plenty, will help to provide good quality fodder during lean period. Subsequent regrowth of grasses will provide more nutritious forage during the period following the harvesting. If harvesting is not possible, deferred grazing be practiced.

Conservation of wild life should be taken into consideration while planning for utilization of rangelands for cattle and other species of livestock in the development programmes. Fodder banks and reserve grazing areas be developed as measures of animal feed security system to cope with natural calamities, viz., drought, flood, prolonged snowfall, etc.

SILVIPASTURE ON RANGELANDS

The importance of browse species increased with increase in aridity and thus their potential should be exploited for range improvement in arid and semiarid regions. Effective protection and subsequent judicious use of degraded savannas holds the key for their improvement. There is a need for developing effective prices for protecting newly planted trees in grazinglands. Identification of plus trees and genotypes suitable for agroforestry and silvipastoral systems need attention. Investigations on frequency and intensity of lopping of fodder trees for sustained fodder and firewood yields are required. Similarly effect of lopping on nitrogen fixation are needed.

ECO-SOCIOLOGY OF RANGE RESOURCES: GETTING PEOPLE INVOLVED

The recommendations included perspectives of people, Government and natural scientists towards rangeland development; the types of responses by the people to ecological changes; local technical
knowledge of the people and making use of the same in the rangeland development; different institutional approaches to range development for ensuring people's participation. It is therefore recommended to make use of the traditional knowledge of the people in developing rangelands and their management.

RANGELAND PROBLEM IN TROPICS AND GRAZING POLICIES

The review of possible management strategies to regulate livestock use on buffer zones and procure actual data on pattern of extensive rangeland use by domestic animal has been suggested.

More research emphasis is needed towards free grazing livestock system including animal, range and human components of pastoralist and forest based ways of life by Govt., Academic and NGO inputs. National Govts. should decide grazing policies of the country, so as to maintain proper pasture health.
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Annual Report 1988

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Bangkok

Dr. S. Chinnamani  
Asstt. Director General  
(Agroforestry)  
Indian Council of Agril. Res.  
Krishi Bhavan,  
New Delhi

Mrs. Priya Prakash,  
Addl. Secretary,  
National Wastelands Development Board,  
New Delhi

Dr. V.B. Eswaran,  
Executive Director  
SPWD, New Delhi

Dr. V.P. Agrawal,  
Forestry Advisor  
SPWD, New Delhi

Dr. Dharam Singh  
SMS, Extension (T & V), Department of Agriculture, UP  
Lucknow

Dr. D.R. Bhumala,  
Rtd Dy. Commissioner, GOI  
Haryana

Dr. L.M. Jeswani  
Rtd. A.D.G., I.C.A.R.  
New Delhi

Dr. K.A. Jalihal,  
Rtd. Director of Extension Education,  
UAS, Bangalore

Dr. A.K. Sinha,  
Sr. Scientist,  
I C A R, New Delhi

Dr. D.J. Sanderson,  
First Secretary (Science),  
British Council High Commission  
New Delhi

Dr. R.J. Haggar,  
Head, Grassland & Ecology Department  
Welsh Plant Breeding Station,  
Aberystwyth

Dr. D.E. Beever,  
Head, Ruminant Nutrition Metabolism,  
Grassland Research Institute,  
Hurley

Dr. Mark A. Smith,  
Office Director, USAID  
New Delhi

Dr. J.S.P. Yadav,  
USAID,  
New Delhi
Dr. J.L. Schuster,
Professor and Head, Deptt. of Range Science,
Texas A&M University
Texas

Dr. Bernard Tontain,
Pasture Agronomist
IEMVT,
Caledonia

Dr. Phillip S. Sims,
Range Scientists and Research Leader,
USDA, Woodward

Prof. Cedric Milner,
Head of Bangor Research Station
Gwyneld, U.K.

Dr. Iaini I. Gordon,
Project Leader
Macaulay Land Use Research Institute
Scotland

Dr. James Munro,
AFRC Institute for Grassland and Animal
Production,
Wales Plant Breeding Station
Aberystwyth, Wales U.K.

Dr. John H. Wilden
Dept. Primary Industries, Queensland
Australia

Dr. D.A. Hockstra,
Agr. Economist ICRAF
P.O.Box 30677, Nairobi, Kenya

Dr. A.K. Oka
Programme Officer, IDRC,
New Delhi

Dr. G.B. Singh,
ICRAF,
Nairobi
LIST OF STAFF

Director : Dr. Panjab Singh, Ph.D.

I. SCIENTIFIC

Division of Plant Improvement

S.R.Gupta Ph. D., Principal Scientist (Economic Botany) & Head of Division
C.B.Singh M.Sc., Scientist Selection Grade (Plant Breeding)
Devendra Singh, M.Sc., Scientist Selection Grade (Plant Breeding)
S.N.Zadoo, Ph.D., Scientist Selection Grade (Genetics & Cytogenetics)
S.N.Tripathi, Ph.D., Scientist Selection Grade (Genetics & Cytogenetics)
S.K.Gupta, Ph.D., Scientist Selection Grade (Plant Breeding)
R.N.Choubey, Ph.D., Scientist Selection Grade (Plant Breeding)
G.P. Shukla, Ph.D., Scientist Selection Grade (Plant Breeding)
M.G. Gupta, Ph.D., Scientist Selection Grade (Genetics & Cytogenetics)
K.S.Kohli, Ph. D., Scientist (Plant Breeding)
J.N.Gupta, Ph.D., Scientist Selection Grade (Economic Botany)
U.P.Singh, M. Sc., Scientist Selection Grade (Economic Botany)
U.S.Misra, M.Sc., Scientist (Plant Breeding)
D.N.Singh, Ph.D., Scientist (Plant Breeding)
M.N.Premachandran M.Sc., Scientist Selection Grade (Genetics & Cytogenetics) (upto 22.8.88)
D.R.Malaviya, Ph.D., Scientist (Plant Breeding)

Division of Agronomy

Menhi Lal, Ph.D., Principal Scientist (Agronomy) & Head of Division
R.P.Singh, Ph. D., Principal Scientist (Agronomy)
A.S.Gill, Ph.D., Principal Scientist (Agronomy)
N.P.Shukla, Ph.D., Scientist Selection Grade (Agronomy)
S.N.Tripathi, M.Sc., Scientist Selection Grade (Agronomy)
Bhoori Singh, Ph.D., Scientist Selection Grade (Agronomy)
K.S.Gangwar, Ph.D., Scientist (Agronomy)
S.D. Gupta, M.Sc., Experimental Scientist (Agronomy)

Division of Grassland Management

P.Rai, Ph.D., Scientist Selection Grade (Agronomy) & Head of Division
K.C.Kanodia, Ph.D., Principal Scientist (Economic Botany)
Vinod Shankar, Ph.D., Principal Scientist (Economic Botany)
B.K.Trivedi, Ph.D., Scientist Selection Grade (Economic Botany)
S.S.Parihar, M.Sc., Scientist Selection Grade (Economic Botany)
Division of Agro-Silvipasture

P.S. Pathak, Ph.D., Principal Scientist (Economic Botany) & Head of Division
R.D. Deb Roy, Ph.D., Principal Scientist (Economic Botany) (Upto 7.5.88)
V.K. Gupta, Ph.D., Scientist Selection Grade (Plant Breeding)
R.C. Singh, M.Sc., Scientist Selection Grade (Agronomy)
M.M. Roy, M.Sc., Scientist Selection Grade (Economic Botany)
S.K. Gupta, M.Sc., Scientist (Economic Botany)
T.A. Khan, M.Sc., Scientist (Statistics)
S.K. Sharma, Ph.D., Scientist (Horticulture)

Division of Soil Science

R.K. Tyagi, Ph.D., Scientist Selection Grade (Geography) & Head of Division
Dashrath Singh, Ph.D., Scientist Selection Grade (Soil Science)
M.R. Pahwa, Ph.D., Scientist Selection Grade (Microbiology)
O.P. S. Panwar, M.Sc., Scientist Selection Grade (Soil Science)
S.B. Tripathi, M.Sc., Scientist Selection Grade (Soil Science)
I.Y.L. N. Murthy, M.Sc., Scientist (Agricultural Chemistry) (upto 31.5.88)
Pradeep Behari, M.Sc., Scientist (Physics)
P.B.N. Murthy, M.Sc., Scientist (Soil Science)
Raj Bahadur Yadava, M.Sc., Scientist (Soil Science)

Division of Plant Animal Relationship

V.C. Pachauri, Ph.D., Principal Scientist (Animal Nutrition) & Head of Division
A. Rekib, Ph.D. Principal Scientist (Animal Nutrition)
R.K. Gupta, Ph.D., Principal Scientist (Organic Chemistry) (upto 11.1.88)
P.K. Kumar, Ph.D., Principal Scientist (Animal Nutrition) (Upto 23.7.88)
A.P. Singh, Ph.D., Principal Scientist (Agricultural Chemistry)
V.S. Upadhyay, M.Sc., Principal Scientist (LPM)
S.C. Gupta, M.Sc., Scientist Selection Grade (Analytical Chemistry)
J.P. Varshney, M.Sc., Scientist Selection Grade (Veterinary Medicine) (upto 6.6.88)
R.S. Upadhyay, Scientist Selection Grade (Animal Nutrition)
N.C. Verma, M.Sc., Scientist Selection Grade (LPM)
A.B. Mojumdar, M.Sc., Scientist Selection Grade (Biochemistry)
L.K. Karnani, M.Sc., Scientist (Agricultural Chemistry)
J.N. Sebastien, M.Sc., Scientist (Organic Chemistry)
B.K. Bhadoria, M.Sc., Scientist Selection Grade (Organic Chemistry)

Division of Seed Technology

P.S. Tomer, Ph.D., Principal Scientist (Agronomy) & Head of Division
R.K. Pandey, Ph.D., Principal Scientist (Agronomy)
S.N. Singh, Ph.D., Scientist Selection Grade (Plant Pathology)
Annual Report 1988

O.P. Dixit, M.Sc., Scientist (Plant Breeding)
G.K. Dwivedi, M.Sc., Scientist (Agronomy)
K.P. Singh, M.Sc., Scientist (Genetics)
V.J. Shivankar, Ph.D., Scientist (Entomology)
S.M. Mishra, M.Sc., Scientist Selection Grade (Soil Science)

Division of Plant Physiology and Biochemistry

R.B.R. Yadav, Ph.D., Principal Scientist (Plant Physiology) & Head of Division
L.P. Mishra, Ph.D., Principal Scientist (Plant Physiology)
N.C. Sinha, Ph.D., Scientist Selection Grade (Plant Physiology)
O.P.S. Verma, M.Sc., Scientist Selection Grade (Plant Physiology)
R.K. Bhatt, M.Sc., Scientist (Plant Physiology)

Division of Plant Protection

S.T. Ahmed, Ph.D., Principal Scientist (Plant Pathology) & Head of Division
S.A. Faruqui, Ph.D., Scientist Selection Grade (Entomology)
K.C. Pandey, M.Sc., Scientist Selection Grade (Entomology)
W.L. Barwad, M.Sc., Scientist Selection Grade (Entomology) (upto 22.9.88)
M.I. Azmi, Ph.D., Scientist Selection Grade (Nematology)
N. Hasan, Ph.D., Scientist Selection Grade (Nematology)
R.B. Bhaskar, M.Sc., Scientist (Plant Pathology)
N.K. Shah, M.Sc., Scientist (Entomology) (w.e.f. 18.6.88)

Division of Agricultural Engineering

Jai Singh, Ph.D., Principal Scientist (Agriculture St. & Proc. Engg.) & Head of Division
P.D. Gupta, Ph.D., Scientist Selection Grade (FMP) (w.e.f. 7.12.88)
R.B. Varshney, B. Tech. Scientist Selection Grade (Soil Water Engg.)
J.M. Sood, M. Tech., Scientist (Soil Water Engg.) (upto 31.8.88)
P.S. Chattopadhyay, M. Tech., Scientist (FMP)

Division of Rural Economic and Biometrics

I.P.S. Yadav, Ph.D. Scientist Selection Grade (Aric. Eco.) & Head of Division
D.P. Handa, M.Sc., Scientist Selection Grade (Statistics)
Mallaya, M.A., Scientist (Economics)
Ram Ashrey Singh, M.A., Scientist (Economics)
Ashok Kumar, M.Sc., Scientist (Statistics)

Division of Extension and Training

O.P. Singh, Ph.D., Scientist Selection Grade (Agronomy) & Head of Division
Maharaj Singh, M.Sc., Scientist (Extension)
Mahavir Singh, M.Sc., Experimental Scientist (Agric. Extn.)
Forage Project (Coordinating Unit)

C.R. Hazra, Ph.D., Principal Scientist (Project Coordinator)
C.R. Rawat, M.Sc., Scientist Selection Grade (Agronomy)
Khubi Singh, M.Sc., Scientist Selection Grade (Statistics)

Dryland Project Centre


Regional Station, Srinagar (J&K)

B.K. Misri, Ph.D., Scientist Selection Grade (Economic Botany) & I/C Station.

Regional Station, Avikanagar (Rajasthan)

Fatch Singh, M.Sc., Scientist Selection Grade (Agronomy) and I/C Station
R.K. Jain, Ph.D., Scientist Selection Grade (Nematology)

Regional Station, Dharwar (Karnataka)

P.K. Jayan, Ph.D., Scientist Selection Grade (Economic Botany) & I/C Station
M.S. Raut, M.Sc., Scientist Selection Grade (Agronomy)

II Technical

A.K. Srivastava, Technical Officer (T-6)
M.S. Sharma, Farm Manager (T-6)
Dodamani Amalappa, Instrumentationist (T-6)
M.M. Rastogi, Technical Officer (T-5)
C.B. Mishra, Technical Officer (T-5)
N.C. Srivas, Technical Officer (T-5)
H.B. Dhingra, Technical Officer (T-5)
S.K. Rajpali, Technical Officer (T-5)
R.B. Mathur (T-4)
R.P. Singh (T-4)
D.K. Bhutani (T-4)
Shrree Ram Sikanya (T-4)
C.P. Gupta (T-4)
Mahi Pal Singh (T-4)
Pramod Kumar Dwivedi (T-4)
Gyasi Lal (T-4)
P.K. Karpe (T-4)
Ram Singh (T-4)
H.N. Sharma (T-4)
B.L. Barodia (T-4)
III Administrative

A. Ramdas, Finance and Accounts Officer
B.N. Rao, Administrative Officer
H.C. Saxena, Administrative Officer
L.S. Sharma, Asstt. Adm. Officer
Gauri Shankar, Asstt. Adm. Officer
O.P. Dubey, P.A. to Director
Subhash Chandra, Superintendent
Ram Baboo Sharma, Superintendent
Veer Singh, Superintendent
S.N. Dubey, Superintendent
K.R. Shashi, Superintendent

IV Auxiliary

V.K. Litoria, Medical Officer
Statement showing head-wise expenditure during 1988-89

(Rs. in lakhs)

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<tr>
<th>Description</th>
<th>NON-PLAN</th>
<th>PLAN</th>
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<tbody>
<tr>
<td>1. Pay &amp; Allowances</td>
<td>107.14</td>
<td>5.17</td>
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<td>2. T.A.</td>
<td>2.50</td>
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<td>3. Recurring Contingencies</td>
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<td>27.97</td>
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<td>4. Non-recurring Contingencies</td>
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<td>1) Works</td>
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<tr>
<td>2) Equipments</td>
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<td>3) Vehicles</td>
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<td>4) Others</td>
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<td>7.53</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>132.64</strong></td>
<td><strong>70.08</strong></td>
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