IGFRI
annual report
1987

Indian Grassland and Fodder Research Institute
Jhansi 284 003
India
PREFACE

It is indeed a great pleasure for me to present this annual report on the activities of the Institute during the year 1987, which happens to be the Silver Jubilee year of the Institute.

Great strides have been made in research on fodder production and its utilization during the last two and a half decades. But still we face serious challenges on the front of forage production. Keeping in view the national priorities a shift has been made in the research areas to augment forage production from the lands which are not being otherwise utilized for other crops. The stress has been laid on speedy transfer of forage production technology as this is the only way to meet this challenge through public involvement in this important task.

PANJAB SINGH
Director
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GENERAL

INTRODUCTION

The livestock husbandry has a vital role in the agricultural economy of India. Scarcity of forage and grazing resources, however, restricts the livestock production at a suboptimum level. Feeding of the huge livestock wealth of India warranted a concerted research effort on forage and grassland production. Recognising the need of a central organisation devoted to research on grasses, grasslands and fodder crops, the Indian Grassland and Fodder Research Institute was established at Jhansi towards the end of the Third Five Year Plan in 1962 by the Govt. of India. This is being administered by the Indian Council of Agricultural Research, New Delhi from April, 1966.

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 agro-climatic 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 designs, 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 investigation and to disseminate knowledge on the subject through organized 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 headquarter of All India Coordinated Project for Research on Forage Crops is also located in the Institute. The Institute also houses research centres of All India Coordinated Projects on (i) Dryland Agriculture (ii) Agroforestry (iii) Under-utilized & Under-exploited plants (iv) Prototype Testing & Feasibility and (v) 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 Regional Stations in J & K at Srinagar, in Rajasthan at CSWRI Farm, in Avikanagar and in Karnataka at Tegur near Dharwar. Sites are being finalized for the research stations in the states of Sikkim and Orissa.

Regional Stations
1. K. D. Farm, SKU, Srinagar (J & K)
2. CSWRI Farm, Avikanagar
3. State Animal Husbandry Department Farm, Tegur near Dharwar (Karnataka)
4. Orissa (site to be finalized)
5. Sikkim (site to be finalized)

RESEARCH COLLABORATION

The Institute collaborates their research work on grassland and fodder production at national and international levels. The details are as below:

All India Co-ordinated 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 Co-ordinated Research Project on Dryland Agriculture

The Centre of All India Co-ordinated 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 Co-ordinated 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 Co-ordinated 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 under utilized plant species for various habitats and farming systems.

AICRP on Development, Testing and 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 in operation specifically for the Buudelkhand region with the objective of forage and tree crop productivity on degraded lands. It is being run at three locations.

TRAINING AND EDUCATION

Training

Diploma Course: Seven Officers from various State Departments undergone the 9 Month Diploma Course Training on Forage Production and its Utilization during the year 1987—88. One lady student also participated.

Short term courses

One three month course (Oct. 1st to December 31st, 1987) was organised in which three officers participated.
In six month course (March 27 - Sept. 26) six foreign student from Vietnam participated under ITEC Programme.

A training programme on social forestry sponsored by NDDB, Anand was organised for nine person from November 24 to December 4, 1987.

A training course on fodder for drought period was organised from Sept. 15 - 24, 1987. This was sponsored by AFPRO in which nine participants sponsored by various voluntary agencies from different states participated.

A Subject Matter Workshop-cum-Seminar which is also a training programme sponsored by Govt of India Ministry of Agriculture on Pasture & Fodder Development was organised from Oct. 15-24, 1987. Six officers from Agriculture and Animal Husbandry department of different states participated in it.

**Education**

The Institute has been recognised as a centre of research by Jiwaji University, Gwalior Bundelkhand Univ. Jhansi and Agra University, Agra for Ph. D. studies. During the year two students submitted thesis. Few more students are pursuing their research work leading to Ph. D. degree.

**EXTENSION**

**Field Demonstration Programme**

During the year, 36 crop demonstration in Kharif and 56 in Rabi were conducted at farmers field in nearby villages i.e. Simardha, Pahadi, Hatnapur, Tejpura, etc.

Under Outreach Programme, field demonstrations were laid at 53 farmer's field of Kanpur and Sultanpur Districts (Ismailpur, Katara Deaspur, Bharisinghpur, Chatterpur, Rasalpur) in collaboration with society for Promotion of Wasteland, Chandrashekhara Azad University of Agril. and Technology and Narendra Dev University of Agriculture and Technology.

The training to farmers was also imparted at their fields through organised programmes. Nearly 5000 farmers and other workers from various parts of the country visited the Institute during the year. They were acquainted with the latest forage production technology.

Similarly the enquiry related to forage production and utilisation were attended through correspondence and personal visits.
Watershed based programme

Tejpura Watershed: The responsibility of survey, planning, training and monitoring of Tejpura Watershed continued to be shouldered by the Institute in collaboration of soil conservation department U. P. Due to its outstanding performance, the project was honoured with KRIBHCO ward 1987 and National Productivity award 1987.

The watershed has an area of 775.7 ha and has five sub-watersheds. There is a seasonal nallah in the watershed of 6.5 km long and this nallah was checked at four different places at the interval of 1.5 km and a vertical interval of 3.5 m each. Each of these check dams has capacity to impound 3 m water. The total cultivated area in the watershed has been raised from 410 to 651 after the soil and water conservation work which has been completed during 1986. In addition there are several gully pluggings which has a capacity of holding 3 m water temporarily. These impounded water resources has the capacity of 15 m ha water and sufficient for irrigating 250 ha land with about 5 cm irrigation. In addition the seepage water that comes to the nallah from the individual fields also contributes to an irrigation of about 150 ha. The number of wells from the initial level of 5 came to a level of 25 during 1986 further raised to 35 which can also provide irrigation to about 70 ha land. This achievement is spectacular considering the initial level of irrigated area was less than 4% of the total cultivated area.

The cropping intensity which was only 82% initially compared to the year 1986 of the watershed was raised to 172% and it further raised to 179% during 1987 inspite of this is one of the severest drought year in this area. The crop productivity was also greatly improved particularly the productivity of vegetable crop during winter season of 1986–87 and the productivity of mustard during this season. During the kharif 1987 which was one of the unprecedented and the arrival of monsoon was late by 45 days, yet the crop productivity in the watershed did not suffer much. The crop damage outside the watershed was to the extent of 80% for most of the crops like pulses and oilseeds and about 70% for the principal crops of this place namely sorghum. Paddy crop outside the watershed failed completely. However the productivity sorghum and the mixed cropping of sorghum with either pigeon pea, green gram and black gram yielded on an average 18–19 quintal on entire watershed basis. The pure crop of sorghum yielded about 20 q/ha on overall basis in the watershed. The yield of some of the pulses like black gram and green gram and some of the oilseeds like sesameum, groundnut and soybean reduced marginally by 10–20% as that of previous year in the watershed as compared to the 80% reduction in yields of these crops outside the watershed area. The paddy crop, however, yielded more than the previous year in the watershed as contrast to its total failure this year outside the watershed.

The water recharge in the wells went initially down by 2-3 m during summer and early monsoon as compared to the comparable season in the year 1985 and 1986. This was mostly
due to the two consecutive droughts year of 1986 and 1987. However, as compared to the water levels in the wells outside watershed area which went down by 6-7 m during the summer and early rainy season whereas the water table dropped in watershed to the tune of 2-3 m.

**Lakara-Karari Watershed**: This Project is a part of the Farming System research where improved technology developed by the Institute is being tested in the farmers field in collaboration with the Development Departments of the State and (CSAU & T, Bharari Campus. It was agreed that under the National Watershed Development Programme for Dryland Agriculture, soil moisture conservation would be done. This will follow crop, pasture, tree plantation and livestock improvement. Though the soil conservation work under the National Watershed Development Programme could not be initiated but the second part has already started. Brief summary of work done in 1987 is as under:

1. Land survey and mapping was taken up.
2. Under crop production demonstration programme, 30 demonstrations on wheat, 12 on soybean and 12 on till+moong were laid out in Rund Karari and Karari villages.
3. The programme was undertaken, which included treatment of sick animals (188 cases) castration 19 cases), vaccination against H. S. (515), R.P. (836), F. Pox (298), RMD (20) and R.D. (280). Artificial insemination in cows (14) and buffalo (20) was done to improve the genetic stock of animal in this area. Poultry chicken (100), Minikit fodder demonstration (12) and Oat seed (50 kg) was also distributed to the farmers.
4. 12 Minikit trial on Sorghum (M. P. chari) and Maize (African tall) were conducted under Fodder Demonstration programme. Because of drought the yield was low (sorghum 102.5 q/ha in Karari and 70 q/ha in Lakara). Maize yield was similar in both the villages which ranged between 95-100 q/ha. Highest yield of 150 q/ha in sorghum and 12 q/ha in maize was recorded, 15 demonstration on berseem cultivation were also laid down.
5. 46,129 trees of different species were planted in 25 ha forest land in village Lakara of which 41,459 survived. Maximum survival rate of 95% was recorded in Losora, Kaith, Vilayati babool and Teak followed by bamboo and Bokain (85-90%). In addition to above bringal and ohielli cultivation was demonstrated in village Lakara.
6. Detailed socio-economic survey of the project area was completed.

**Organization of Kisan Mela/Kisan Gosthi/Exhibitions**

Institute organized an All India Farmers fair wherein large number of farmers, State officials, extension workers from all over the country (Tamil Nadu, Assam, Tripura, Haryana, Punjab, Rajasthan, etc) participated. On this occasion a large agriculture exhibition
and Kisan Gosthi were arranged with the help of several ICAR Institutes, Universities and State Departments. The magnificent pavillions were installed to demonstrate the technologies/achievements. The Field days were also organised in several villages in order to create awareness for fodder production among farmers. The Institute also participated in the Bundelkhand Development Exhibition for one month.

**SYMPOSIA/SEMINARS/WORKSHOPS**

1. All India Coordinated Research Project on Forage Crops Annual Workshop held at HPKVV Palampur from 13–15th April 1987.

2. Group meeting of All India Coordinated Research Project held at IGFRI, from 7–8 August 1987.


5. Subject matter workshop-cum-seminar on Fodder and Pasture Development sponsored by Ministry of Agriculture, Govt. of India, New Delhi and organised by IGFRI, Jhansi from 15th to 24th December 1987.

**STAFF**

The Institute had a sanctioned strength of 245 scientific, 150 technical, 91 administrative, 174 supporting and 36 auxiliary staff. The staff position as on 31.12.87 is given in Appendix–I.

**FINANCE**

During the year 1987–88 the Institute has utilised the budget grant of Rs. 159.52 lakhs of which Rs. 45.03 lakhs was utilised under plan and remaining Rs. 114.49 lakhs under non-plan. The capital expenditure was to the tune of Rs. 3.99 lakhs. During the year the revenue of Rs. 5.10 lakhs was realised. The headwise expenditure details are given in Appendix II.

**FACILITIES**

**Central Research Farm**

The Institute had 574 hectares which includes the area under campus. During the year one field laboratory was inaugurated by Hon’ble Union Minister of Agriculture Dr. G. S. Dhillon. Thus the number of field laboratories at the farm became four. With a view to combat the drought, irrigation facilities at the farm were strengthened. The remote sensing survey of available potential of agriculture at the farm was conducted. One tubewell was installed in the Plant Improvement division area. The work for other two tubewells has been initiated.
Irrigation channels were repaired. The farm has varying topography with rakar, parwa, kabar types of soils. During the year two goat/sheep paddocks were constructed and cattleshades of PAR Division were renovated. Similarly, the old shade in Agronomy Division was repaired. Two culverts were also constructed during the year.

The Administrative Wing and Research Laboratories comprises of five laboratory wings and one administrative wing. It has Conference Hall, Committee rooms 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 service for chemical analysis and Central Instrumentation Laboratory is equipped with sophisticated electronic equipments.

Library
The Institute library procured 580 titles of books, besides, the books received on complementary basis during the year. The library subscribed for 100 Indian and 85 foreign journals. The reprographical services were also strengthened.

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 catagories. It has also a community centre with necessary infrastructure for providing better social life to the residents. 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 needs of visitors and trainees.

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

In the year 1987, total rainfall of 828.2 mm was received in 43 rainy days (Table-I) which is 88.5% of normal rainfall of the region. The late onset of monsoon in 1st week of July (27th standard week) and a break in monsoon for 3 weeks (29 to 31st standard week) was observed. Again the rainfall was not well distributed though the monsoon continued up to 3rd week of September (38th standard week). Total monsoon rain of 619 mm was recorded in 12 weeks with 2 breaks against normal rain of 870 mm during this period. The late rain of 110 mm during October in two rainy days helped in the sowing of rabi crops. The highest maximum temperature 47.4°C was recorded on 8th June and lowest minimum temperature of 2.5°C was recorded on 8th December.

Table -1: Temperature, Relative Humidity (RH) and Rainfall during 1987

<table>
<thead>
<tr>
<th>Month</th>
<th>Temperature</th>
<th>RH in %</th>
<th>Rainfall in mm</th>
<th>No. of Rainy days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max.</td>
<td>Min.</td>
<td>Period I</td>
<td>Period II</td>
</tr>
<tr>
<td>Jan.</td>
<td>24.4</td>
<td>7.2</td>
<td>71</td>
<td>28</td>
</tr>
<tr>
<td>Feb.</td>
<td>30.3</td>
<td>72</td>
<td>72</td>
<td>23</td>
</tr>
<tr>
<td>March</td>
<td>35.0</td>
<td>17.0</td>
<td>60</td>
<td>18</td>
</tr>
<tr>
<td>April</td>
<td>40.8</td>
<td>22.2</td>
<td>45</td>
<td>11</td>
</tr>
<tr>
<td>May</td>
<td>42.8</td>
<td>25.5</td>
<td>44</td>
<td>14</td>
</tr>
<tr>
<td>June</td>
<td>44.2</td>
<td>29.8</td>
<td>53</td>
<td>28</td>
</tr>
<tr>
<td>July</td>
<td>38.1</td>
<td>26.3</td>
<td>70</td>
<td>43</td>
</tr>
<tr>
<td>Aug.</td>
<td>35.3</td>
<td>23.8</td>
<td>83</td>
<td>58</td>
</tr>
<tr>
<td>Sept.</td>
<td>33.3</td>
<td>23.7</td>
<td>83</td>
<td>50</td>
</tr>
<tr>
<td>Oct.</td>
<td>33.9</td>
<td>18.1</td>
<td>72</td>
<td>35</td>
</tr>
<tr>
<td>Nov.</td>
<td>30.1</td>
<td>9.7</td>
<td>73</td>
<td>29</td>
</tr>
<tr>
<td>Dec.</td>
<td>24.8</td>
<td>6.6</td>
<td>84</td>
<td>34</td>
</tr>
</tbody>
</table>

Note: RH in % refers to Relative Humidity during Period I and Period II.

The highest maximum temperature 47.4°C was recorded on 8th June and lowest minimum temperature of 2.5°C was recorded on 8th December.
DIVISION OF PLANT IMPROVEMENT

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

During the year 92 accession of grasses and 145 of legumes and other conventional and unexploited species were added.

1.1 Grasses

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

Establishment

In grasses 22 Panicum antidotale, 15 Dichanthium annulatum, 20 Heteropogon contortus, 23 Iseilema lesum, 7 Sehima nervosum and 5 exotic Cenchrus ciliaris accessions were raised in nursery in May-June and transplanted for evaluation trials in July. Except four entries of Sehima, all germinated and showed 60 to 80% establishment.

Dicanthium annulatum


Sehima nervosum

Preliminary evaluation revealed remarkable diversity in 22 new and 43 old accessions evaluated in leaf colour, tiller density, fodder yield and regrowth pattern. The mortality during establishment of the transplants varied from 46–68%. The promising high yielding types having regenerative potential during winter months are IG-75, 351, 2033, 2036-1, 2039 and 2040.

Chrysopogon fulvus

Preliminary evaluation of 38 accessions revealed 30-40% variations in the establishment. The yield in all the entries was exceptionally low during first year but in several
entries it increased by 3 to 4 times in the second year. The promising high yielding leafy selections are IG-2007, 2014, 2029 and 2160 with yield ranging between 1.36–2.21 kg/m².

1.2 Cultivated legumes

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

Establishment

The cluster bean (Cyamopsis tetragonoloba), Moth bean (Vigna aconitifolia), Vetches (Vicia spp.) and Senji (Melilotus spp.) were evaluated and Vigna unguiculata and Vigna umbellata collections were maintained.

Cluster bean (Cyamopsis tetragonoloba)

During the kharif 1987 guar was evaluated under three steps (i) stations trials (ii) co-ordinated trials and (iii) maintenance of gene pool.

In advance varietal trial-11 photo-thermo-insensitive varieties were further evaluated for fodder and grain production potential with three checks. Selections IL 1019–1, 212–1, 2402–1, 2395–2 and 1539–1 were significantly superior over HFG–119 (Check) for fodder while 212–1 and 1539–1 were also better grain yielder over HG–75.

Table-2: Fodder and grain yield of different cluster bean varieties.

<table>
<thead>
<tr>
<th>S No.</th>
<th>Varieties</th>
<th>Green fodder yield q/ha</th>
<th>Dry fodder yield q/ha</th>
<th>Grain yield q/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>LL 1019–1</td>
<td>285.4</td>
<td>87.8</td>
<td>14.7</td>
</tr>
<tr>
<td>2.</td>
<td>212–1</td>
<td>280.4</td>
<td>59.3</td>
<td>166</td>
</tr>
<tr>
<td>3.</td>
<td>2402–1</td>
<td>269.3</td>
<td>60.7</td>
<td>10.5</td>
</tr>
<tr>
<td>4.</td>
<td>2395–2</td>
<td>265.4</td>
<td>58.5</td>
<td>132</td>
</tr>
<tr>
<td>5.</td>
<td>1539–1</td>
<td>263.7</td>
<td>57.5</td>
<td>17.1</td>
</tr>
<tr>
<td>6.</td>
<td>HFG–119 (Check)</td>
<td>224.7</td>
<td>50.2</td>
<td>7.5</td>
</tr>
<tr>
<td>7.</td>
<td>HG–75 (Check)</td>
<td>213.8</td>
<td>52.0</td>
<td>15.6</td>
</tr>
</tbody>
</table>
Based on the Performance during last three years (1985-87) selection 212-1, 1019-1, 2325-5 and 24-1 were found superior over both the checks HFG-119 and HG-75 (Table-2). Variety 212-1 was entered in coordinated trials and performed well for both grain and fodder yield.

Coordinated trials

1. For Forage: Final evaluation trial comprising of 10 entries was sown and left due to prevailing drought. Plant population per unit area was very poor. No entry was found superior over the check. Amongst, GL-14 has yielded better (171.2 q/ha) against HFG-119 (168.8 q/ha).

In initial evaluation trial S-212-1 was found significantly better over the check for green fodder and dry fodder per unit area followed by HGS-204 and 201.

Table-3: Green and dry matter production of different Guar varieties

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Green fodder yield q/ha</th>
<th>Dry matter yield q/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGFRI 212-1</td>
<td>146.6</td>
<td>41.5</td>
</tr>
<tr>
<td>HGS-204</td>
<td>142.1</td>
<td>42.3</td>
</tr>
<tr>
<td>HGS-201</td>
<td>135.4</td>
<td>41.2</td>
</tr>
<tr>
<td>HGS-119</td>
<td>108.4</td>
<td>35.4</td>
</tr>
</tbody>
</table>

2. For Grain: Seven entries were tested under evaluation trial. All were statistically at par with the superior check HG-75, however HG 20-2 was found better yielder followed by RGC-950, 954 and HGS-37 which gave 12.5, 12.1, 11.6 and 11.3 seed q/ha, respectively.

In initial evaluation trial, HGS 165 (14.1 q/ha) was significantly superior followed by IGFRI-212-1 GAU-34 and HG-75/87 yielded 11.9, 10.9 and 10.5 grain q/ha, respectively.

Moth bean (Vigna acontifolia)

Ten promising lines were identified during the kharif 87 on the basis of high leaf/stem ratio and were further evaluated. Data indicated that IL 1073-1, 1202-1 and 2938
(locally collected) were promising in fodder production potential with 158.5, 158.3 and 140.1 q/ha GFY and 27.9, 28.3 and 25.8 DM q/ha, respectively. Selection 1202–1 was observed as late maturing type (150 days) while 1073–1 and 2938 matured in 120–125 days.

1.3: Range legumes and other forage species

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

Observations on preliminary evaluation and rejuvenation were recorded on 42 collection of Indigofera, 117 of Desmodium, 11 of Macroptelium lathyroides, 60 of Clitorea ternatea, 24 of Phaseolus, spp., 65 of Stylosanthes spp., 8 of Centrosema spp. and 41 miscellaneous spp.

Regrowth potential of 19 selection of Indigofera spp. were recorded on 11 prostrate and 8 erect type accessions belonging to 7 species indicated that among the prostrate types I. subulata (IL 1519–1) followed by I. brevipes (IL 1498–1), I. cievinella (IL 1496–2) gave better green forage yield of 4.12, 2.10 and 2.57 kg/m²/yr. Out of eight erect selections, I. semitrijuga (IL 1515–2), I. sumatrana (1516–1) and I. tetlensis (1505–2) showed best potential giving green forage yield of 6.94, 6.58 and 5.64 kg/m²/yr.

Vigna umbellata is sensitive to intra-specific competition. The detrimental influence of increasing density from 1 to 4 per pot and similarly under field conditions was observed in both green fodder yield and grain production. One plant/pot gives about four to five times more fresh weight and seed output than 4 plants/pot. The ratio were 1 : 4.49 for GFY and 1 : 4.92 for grain yield.

Wide variability in different growth parameters in 25 accessions of Rivea hypocratesiformis was observed.

PI-2 PRODUCTION AND QUALITY BREEDING IN FODDER GRASSES

2.1 Production and quality breeding of fodder Sorghum

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

Twenty one strains of Sorghum, developed earlier through hybridization were evaluated in a replicated trial for single cut system with H. D. 2 as a check. Rio x HDI–p₁₂ gave highest green fodder yield (341.4 q/ha) followed by MPC x 491–10 (340.6 q/ha), MPC x 491–6 (340.5 q/ha) and Rio x HDI–P₁ (340.3 q/ha) as against the check (338.8 q/ha).
The highest dry matter yield (140.5 q/ha) was given by strain 4-1-1 4 followed by Rio x HD-1-P12 (140.53 q/ha). The dry matter of Rio x HD-1-P12 was at par with the check HD-2 (140.4 q/ha) but the strain excelled in green and dry matter production.

Eight strains of sorghum, developed recently through hybridization were evaluated for single cut system. M. P. Chari, widely adapted variety, was used as a check. Date showed that all the strains except one (C-14-12-1) were superior in yields from 118 to 29.6 over the check: strain D-11-2-1 was the highest yielder in green fodder (403.3q/ha) followed by D-11-1-1 (375.3 q/ha) and M-1-3-1 (350.4 q/ha) as against the check (311.2 q/ha). In dry matter production: D-11-2-1 having 132.5 q/ha yield was 41% higher and D-23-2-1 was 17.1% superior (109.5 q/ha) over the check (93.5 q/ha). Remaining strains were marginally superior. D-11-2-1 was superior both in terms of green fodder as well as dry fodder yields.

Advancing of Hybrid generations

F1 generation of 9 crosses was raised, and colchicine treatment was given to raise amphidiploids. Seeds for F2 have been collected.

Two hundred and one F3 progenies of thirty one crosses were raised in single rows. 153 promising plants from outstanding progenies were selected for F4 generation.

Forty two F4 progenies derived from three way seven crosses and fifty six progenies of six crosses were raised. Fifty plants from promising progenies were selected for advancing to F5 generation.

Hybridization

Interspecific crosses were attempted using two male sterile lines viz. m. s. 296A and m.s 2077A, and three spp., S bicolor, S virgatum S taecioleatum. The seeds obtained from these crosses will be grown next year to raise F1 generation. Cytogenetic studies in these species and their hybrids were initiated.

Multiplication

5 promising strains were raised for seed multiplication.

Coordinated trial

Five entries of sorghum viz. JHS-20, JHS-22, JHS-23, JHS-29 and HD-2 were contributed for testing on All India basis under Sorghum Coordinated Project.
2.2 Production and quality breeding in fodder oats (*Avena sativa* L.)

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

**Genetic Resources**

671 new accessions of oats comprising *Avena sativa*, *A. sterilis*, *A. strigosa*, *A. maroccana*, *A. byzantina*, *A. barbata*, *A. brevis*, *A. abyssinica*, *A. fatua*, *A. nuda* and intrageneric hybrid derivatives were procured from USA, Hungary and Australia. Out of these, 92 lines were evaluated for various plant traits. The oat genotypes Black mesdog, Saturn, Diadem, Veli Hankijan valco, Rodney and Lodi were found promising forage types having leafiness and longer growth duration.

**Intervarietal hybridization and segregating progenies**

Attempts have been made to cross promising forage oat lines viz., Cuahotec, Diadem, Paramo, Lodi, Saturn, Veli having longer growth duration with medium duration lines viz., JHO-831, OS-6, OS-338 and JHO-817 so as to recover forage genotypes suitable for the multicut system.

Promising forage hybrids identified are JHO-851 × Paramo, Nodaway × UPO-94, OS-6 × Chihuahua and JHO-851 × Chihuahua.

**Amphiploid progenies of *A. sativa* × *A. maroccana***

In all 571 progenies of *A. sativa* × *A. maroccana* crosses were grown in C2. Out of these, 147 plants were selected for generation advancement. Selection was based on overall plant traits desirable for a promising forage genotype. All these selected plants possessed good seed fertility without shattering. Rest of the progeny rows were bulked for further testing.

**Back cross progenies of pentaploid hybrid between *A. sativa* and *A. maroccana***

To introgress the desirable genes of wild species *A. maroccana* to cultivated *A. sativa*, 45 plants in BC_{2}F_{2} were analysed for morphological and cytological parameters. There was a wide range of variation for plant height, peduncle length, ear length and number of spikelets per panicle. Correlation coefficients worked out between different character combinations exhibited that the trend of correlation changed in two back cross generations in case of plant height vs. peduncle length, peduncle length vs. panicle length and panicle length vs. spikelets/panicle. In general, the magnitude of correlation coefficients was reduced due to further back crossing.
Meiotic analysis indicated that majority of the plants had $2n=42$, chromosomes approaching the normal euploid one. The analysis of BC$_2$ plants showed that chromosome number tended to stabilize around the number of recurrent parents ($2n=42$).

**Induced autotetraploid of A. strigosa**

Thirty one plants of C$_1$ progeny of induced autotetraploids were grown and it was revealed that they had larger leaf size and longer plant height than their diploid parent. However, they showed lesser seed fertility than diploid one. Out of these, 26 plants possessed $2n=4x=28$, 3 plants had $2n=(4x+1)=29$ and a single plant had $2n=4x-1=27$ chromosomes. Analysis of data also indicated a negative correlation between quadrivalent frequency and pollen stainability whereas bivalent frequency and pollen stainability were positively associated.

**Strains**

Based on the superior performance of 3 newly developed strains through selection in station trials, JHO-861 JHO-862 and JHO-863 were identified for testing in All India Forage Coordinated Project trials. They give higher forage yield ie. JHO-861 (772 q/ha), JHO-862 (707 q/ha) and JHO-863 (688 q/ha) than the check OS-6 (544 q/ha).

**Variatel testing under All India Coordinated Project for Research on Forage Crops**

Oat strains tested in initial evaluation trials (IET) and final evaluation trials (FET) were as follows :

IET (single cut) : JHO-841
IET (multicut) : JHO-841
FET (single cut) : JHO-813, JHO-817, JHO-822, JHO-825 and JHO-826
FET (multicut) : JHO-822 and JHO-829

**Identification of oat variety JHO-822 for release in Central Zone of the country**

The forage oat variety JHO-822 was found suitable for its cultivation in multi cut system in the central zone of the country as its performance period superior in breeding trials of Forage Coordinated Project for a period of 4 years. Consequently, this variety has been identified for release in central Zone of the country during group meeting of the All India Coordinated Forage Project held at Jhansi, 7–8 September 1987.

The other oat strain JHO-810 was also identified as a promising forage oat (single cut) for Kashmir valley. However, it was finalized that this variety may be tested for another
year in the final evaluation trial with other entries before its final release.

2.3 Development of high yielding and nutritious varieties of fodder bajra and Napier-bajra hybrids

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

Evaluation of improved interspecific hybrids of Pennisetum

A trial on an improved Bajra–Napier hybrid (BN–82048) and a trispecific hybrid (D-379) was laid out in February 1987, to compare their performance with NB–21. The trispecific hybrid D-379 produced highest GFY and DMY (877 q and 153.6 q), respectively.

The forage quality of both the new hybrids was superior to that of NB–21. These two hybrids had higher crude protein content and lower NDF, ADF lignin and silica than NB–21. BN–82048 had very low lignin i.e. 7.10 and 8.78 percent in comparison to that of NB–21 i.e. 10.32 and 13.10 for the May and August cuts studied for quality parameters.

Final evaluation trial of Bajra

A trial on 12 bajra varieties was conducted during kharif 1987. The varieties PCB-15 and UUJ–1 were superior in green fodder yield while highest dry mater yield was obtained from UUJ–1 and MBFH–1.

Evaluation of superior hybrids and line × tester analysis

Observation were recorded on 69 pearl millet hybrids. Out of these 36 hybrids were planted for line × tested separately. Three promising hybrids viz. Pb. 405 × P 150-12-1, (JFHB-9) Pb, 405A × M 130 (JFHB-21) and Pb. 405 × IP 5939 (JFHB–53), were indentified superior in forage yield and its attributes and were selected for further study and multiplication.

Advancement of generation

238 segregating lines were sown. Most of these lines were advanced and selected for uniformity.

Development of new male sterile lines

One line in F₄ progeny of crosses involving ICms 81 B was observed to be male sterility maintainer and the hybrid of its F³ progenitor with ICms 81 A was found to be sterile. The sterile progeny was backcrossed with suitable F₄ plant and the backcross programme for development of a tall male sterile line was initiated.
Interspecific crossing

The trispecific hybrid, D-379, was used as a pollen parent and crossed with ICms 81 A repeatedly to develop new apomictic, perennial hybrids.

The F₁, BC₁ and BC₂ plants of Pennisetum americanum x P. orientale cross were extensively pollinated with P. americanum pollen. Seeds were harvested from such crosses for further advancement and for studies on the extent and mechanism of recurrent addition of P. americanum genome.

Evaluation of D-379 as comparison to range grasses

A trial was planted in August 87 to compare the performance of D-379 in rainfed conditions with that of Dichanthium annulatum and C. ciliaris. It was observed that D-379 produced 114.3 and 305.5 percent higher green fodder than the two grass species in the first cut after 4 months of establishment. Regeneration and other studies will follow.

Studies on capillary method for induction of tetraploidy in Pennisetum schweinfurthii

Repeated attempts to induce tetraploidy in the wild species P. schweinfurthii to bridge the gap of chromosome number existing in it and P. purpureum using the capillary method were unsuccessful, suggesting modification of this method or use of other methods.

Entry in All India Trials

Five Pennisetum interspecific hybrids viz., BN-82048, BN-86061, BN-86073 BN-86089 and D-379 were accepted for entry and final evaluation trials of the All India Coordinated Project for Research on Forage Crops during its XIIIth workshop held at Palampur from 13-15 April 1987.

2.4 Breeding superior varieties in forage maize (Zea mays L.)

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

In a late maturing variety African tall, progenies of 200 plant including intravarietal crosses were grown in kharif. At maturity one plant from each progeny was selected and seed bulked for a mass selection programme.

Pl-3: BREEDING SUPERIOR VARIETIES OF CULTIVATED FODDER LEGUMES

3.1 Breeding varieties for high fodder yield and quality in cowpea

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

298 lines of cowpea germplasm were evaluated for six strains viz, days to flower initiation, time of fruit maturity, extent of defoliation during fruiting period, regrowth potential, vigour of plants and growth habit of the plants. Based on these character associations the germplasm have been classified into eleven groups as pulse type, fodder type, dual type and early and late flowering types.

Advanced evaluation trial of promising selection in F₆ progenies

Nine cowpea selection made from F₆ progenies were evaluated in a randomised block design for fodder yield. Significant differences in fodder yield were observed between the cultivars. The control EC-4216 was significantly inferior to all the varieties in yield. The high yielding selections were Hy 8 P₆-12 (416.53 q/ha), Hy 8 P₆-4 (399.96 q/ha) and Hy 6 P₆-3 (387.46 q/ha). and HY6 P₆-6(379.13 q/ha) The increase in yield over the control ranged from 82 to 100%.

All India Coordinated trials on forage cowpeas

Two coordinated trials (i) final evaluation trial (KBT-1) and (ii) Initial evaluation trial (KBT-2) comprising 10 and 24 varieties respectively were conducted.

In the final evaluation trial (KBT-1), nearly all the entries were superior to the control EC-4216. The varieties which were significantly superior to the check were IFC-8401 (410.92 q/ha), IFC-8402 (391.51 q/ha), UPC-420 and UPC-2201 (380.43 q/ha), UPC-5286 (354.03 q/ha) UPC 287 (335.95 q/ha).

In the initial evaluation trial (KBT-2), most of the varieties performed better than the control EC-4216. Four entries were significantly superior to the check yielding IFC-8503 (420.67 q/ha), IFC-8502 (419.25 q/ha), IFC-8501 (415.08 q/ha) and UPC-8701.29 q/ha) green fodder.

Advancing Hybrid generation

F₂ seeds of the 13 hybrids made in 1986 have been obtained.

Entry in the coordinated Trials

Three promising cowpea cultivars would be entered in the coordinated trials for 1988.

Seed multiplication

The seven promising entries made in the All India Coordinated Trials have been multiplied and a sizeable amount of seed obtained.
3.2 Strain building in Lucerne for fodder yield and peristance

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

Gane Pool

185 germplasm lines of lucerne including 19 exotic collections grown in two row plots were evaluated for fodder and seed yield. 60 lines of seven annual medics species namely *M. aculate*, *M. polymorpha*, *M. orbicularis*, *M. littoralis*, *M. rigidula*, *M. tornata* and *M. truncata* grown in single row plots were evaluated for forage productivity.

Breeding

Single plant progenies of nearly 400 plants from polycross nursery were sown in single row plots for observation on morphological vigour, regrowth potential, fodder and seed yielding ability after December.

Variatel Trials

All India Coordinated Trials: Final evaluation trial comparing 7 lucerne varieties received from the forage coordinator along with our own standard variety IL–244 are being evaluated in a replicated trial. The data of forage yield will be recorded.

Another trial with 8 promising selections were grown in replicated trial. The data on fodder yield, regrowth potential and seed yield will be recorded.

Preliminary evaluation trial of lucerne with seven entries have been grown in a replicated trial. The data on fodder and seed yield will be recorded.

3.3 Genetic improvement of *Trifolium* species with special reference to Egyptian clover

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

*Trifolium alexandrinum* L.

Variatel trial: Significant varietal differences were observed in the first cut in a 20 entry varietal trial. Estimates of heritability and gentic advance were moderate to low. G×E interactions showed varietal and varieties × environment (linear) to be non significant. Correlations among the cuts were low and negative between the first and second cut.

Breeding behaviour

Out of 366 progenies evaluated, 299 progenies were homogeneous and 67 segregated
for one or more than one character viz. 24 for tallness, 44 for leaf thickness, shape size and number; 3 each for chlorophyll content in leaves and branching pattern, 8 growth habit and 40 for duration/period of maturity, one each for petal colour and inflorescence.

Hybridization

A total of 337 intervarietal crosses in $6 \times 6$ diallel showed 6.4% seed set. Five crosses viz., BL-10 X BL-42, BL-42 X HFV-114, BL-42 X Wardan, JB-3 X Mescavi and JB-3 X HBF 114 set seeds. Other 285 crosses attempted for multifoliate plant X normal plant and interspecific ones showed 1.4% seed set. The crosses pentafoliate JHB-64 were successful.

Mutation Breeding

Two strains BL-10 and JB-3 were given gamma rays seed treatment for 50 kR, 75 kR, 100 kR and 150 kR and grown as $M_1$ generation. Selection for 53 multifoliate type and 18 gigantic plant types were done. Seeds from each treatment were bulked separately to raise $M_1$ generation.

Iometrical Studies

Based on two consecutive cuts, number of leaves, leaf weight, and stem weight were found to be positively correlated to forage yield at phenotypic and genotypic levels.

Path analysis showed maximum direct effects of leaf weight and stem weight on forage yield. The magnitude of indirect effects was attributable to several growth characters. Leaf and stem weight appear to be important criteria for improvement in berseem.

Selections

The following selections of breeding importance were made late types with variation for shape/size/thickness of the leaflets (13), plant type (13), Inflorescence variants (13), multifoliate (18), gigantic (12), late and erect (6), dwarf and small leaves (3), growth habit variation (3), tall (5), early (2), purple flowers (3), late/tall/gigantic/erect/high chlorophyllous (14), dwarf (4). $P_2$ dwarf (6), $P_3$ tall (6), late dwarf (4) and late (34).

Entries in the All India Coordinated Trials

Two entries JHB-220 and JHB-146 have been promoted to final evaluation trial and two new entries JHB-ISB 86 and JHB-C 87 were entered in the initial evaluation trial of the coordinated programme.
Trifolium species

Exotic collections of *T. rapens*, *T. cherclli*, *T. pratense*, *T. subterraneum* and *T. resupinatum* were grown in for seed multiplication. A parallel selection programme in Shaftal was intensified from natural populations at Bharari Farm and 16 gigantic types were selected which showed better promise than exotic collections (viz. EC-177581, EC-177583 and EC-177584) for forage attributes.

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

(D. N. Singh)

Field bean (*Lablab purpureus*), a biennial crop was sown in July 1987, and it will mature by April/May. The observations given below are up to prematurity stage of the crop.

Collection, maintenance and evaluation of genetic stock

175 genetic lines including 30 entries from NBPGR, New Delhi and 15 local plants selection were evaluated for fodder attributes. Remarkable genetic variability in var. *lignosus* and var. *typicus* with respect to plant and flower morphology, growth and flowering attributes, and pod characteristics were observed. The genetic lines were classified into fifteen separate groups. Promising genotypes for earlyness and fodder have been selected for exploitation in breeding programme.

Advanced yield trial on selected strains

Twenty genetic lines/strains, including six under All India Coordinated trials were evaluated for fodder and grain attributes in RBD trial. Analysis of the data on plant length, number of branches per plant, days to flowering initiation and 50% flowering, plant growth vigour, fodder yield and dry matter percentage in the fodder showed that these genetic lines differ significantly for all the characters except for plant length. The relative yield performance of the genotypes exhibited that early genotypes were poor yielder (Table-4). Promising strains for fodder yield were S-27, S-32, S-2216, S-23 and S-2218. The green fodder yield (GFY) for these strains was above 220 q/ha (in single cut).

Inter-varietal hybridization

Four crosses were made using var. *lignosus* (S-2216 and S-32) as female parents and var. *typicus* (early types) as male parents,
Advancing of the hybrid generations and selection

Forty eight F₃ progenies of the four crosses viz., S-1649-I × S-22, S-1649-I × S-33, S-1649-I × S-16 and S-33 × S-22 were raised and they are under evaluation.

Seventy five F₉ progenies of the seven crosses were raised. The number of progeny for each cross varied between 3 to 15. Progenies of the crosses S-14 × S-20 and S-1649-I × S-129 exhibited lush green foliage and cold tolerance in late winter. They had high regeneration potential also. Progenies of the cross S-1649-I × S-31 had determinate growth and high pod number.

Selection on mutant population

Seven selected mutants (M₄) obtained through gamma irradiation were raised in progeny plots. Few desirable types have been identified.

Seed multiplication

Ten promising strains including those under All India Coordinated Trials were raised for seed multiplication.

Entry into All India Coordinated Trials

Six top ranking strains viz., IGRFRI-S-2214-II, S-1649-I, S-2216, S-32, S-13-I and S-27 were entered this year in the All India Coordinated Trials in the name of JLP-1, JLP-2, JLP-3, JLP-4, JLP-5 and JLP-6, respectively.
Table 4: Relative performance of promising strains in field bean (*Lablab purpureus*) (9 out of 20) (Year 1987—88)

<table>
<thead>
<tr>
<th>Strains/genetic lines</th>
<th>Days to 50% flowering</th>
<th>Fodder yield (q/ha)</th>
<th>Green pods/plant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Green</td>
<td>Dry</td>
</tr>
<tr>
<td><strong>S-27</strong></td>
<td>125.3</td>
<td>237.8</td>
<td>68.5</td>
</tr>
<tr>
<td><strong>S-32</strong></td>
<td>118.7</td>
<td>225.8</td>
<td>64.9</td>
</tr>
<tr>
<td><strong>S-2216</strong></td>
<td>114.0</td>
<td>224.2</td>
<td>64.6</td>
</tr>
<tr>
<td><strong>S-23</strong></td>
<td>114.3</td>
<td>223.6</td>
<td>61.5</td>
</tr>
<tr>
<td><strong>S-2218</strong></td>
<td>121.3</td>
<td>219.0</td>
<td>51.9</td>
</tr>
<tr>
<td><strong>S-29</strong></td>
<td>114.6</td>
<td>214.5</td>
<td>53.8</td>
</tr>
<tr>
<td><strong>S-13-I</strong></td>
<td>125.6</td>
<td>190.9</td>
<td>48.9</td>
</tr>
<tr>
<td><strong>S-31-II</strong></td>
<td>107.0</td>
<td>168.7</td>
<td>44.0</td>
</tr>
<tr>
<td><strong>S-84</strong></td>
<td>105.7</td>
<td>163.8</td>
<td>43.8</td>
</tr>
</tbody>
</table>

General Mean (GM) 122.1
SE of diff. between 2 treat. Mean 1.8
SE of diff. from GM 1.2
4.1: Varietal Improvement for Forage Yield and Quality in Range Grasses

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

*Dichanthium* Species:

Genotypic evaluation and maintenance

95 genotypes of different *Dichanthium* spp. were evaluated for drought resistance and 19 B, 496, 497, 493, 576 were found to be quite resistant.

Varietal evaluation

10 promising strains of 4 spp. and one natural hybrid were evaluated in replicated trial to identify their fodder production potential. Data on growth parameters were recorded. Wide variation was observed in plant characters on one cut. The highest green fodder yield was produced by IGFRI-585 followed by 495 (63.1 q/ha) and 19 A (61.7 q/ha). The highest dry matter yield exhibited by 495-1 (26.9 q/ha) which was followed by IGFRI-585 (25.7) and 19 A (23.4 q/ha). Significant differences were found in both green as well as dry matter yields.

*Cenchrus ciliaris*:

Genotypic evaluation and maintenance

85 genotypes are maintained. The following 7 genotypes showed considerable degree of drought tolerance 660, 673, 686, 696, 8-4-3, 8-4-10 and Cp-72:

Varietal evaluation

10 strains were evaluated in a replicated trial for growth parameters on two cuts. Data revealed that wide range of variation for plant character was observed. The pooled data showed that highest yield was produced by IGFRI-3108 (209.9 q/ha) which was followed by 679 (208.9 q/ha) and 678 (204.6 q/ha).

The highest dry matter yield on pooled data basis was obtained from 660 (66.3 q/ha) which was followed by 678 (65.5 q/ha) and 679 (64.2 q/ha.)
4.2: Breeding superior varieties of range legumes for the improvement of pasture

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

Trispecific hybrids of \((Atylosia albicans \times Atylosia scarabaeoides) \times Atylosia cajanifolta\) in F_2 generation have been raised in 12 rows along with 3 parental lines. In each line, 60 plants spaced 0.5 m between the plants have been maintained. The segregating progenies within and between the different lines (each line originated from different F_1 plants) have been observed for different growth characters. The trispecific hybrids manifest wide diversity in growth habit e.g. erect, semi-erect, spreading, semi erect with branch and dropping, determinate and indeterminate types. Variation in flowers colour, leaf shape/size, length of branches, vigour etc. have been marked. The plants with appressed branching pattern, high amount of leafiness and pods and apparently high biomass yield types have been selected for further study.

PI-5: PHYLOGENETIC STUDIES IN FORAGE AND PASTURE SPECIES

1 Cytogenetical studies in cultivated legumes

(S. N. Tripathi)

Trispecific Hybrids in Cajaninae

Cytomorphogenetic characteristics of the parents viz., \(Cajanus cajan\) (seed parent) and F_1 of \(Atylosia albicans, Atylosia scarabaeoides\) (pollen parent) and their F_1 hybrid are summarised in (Table-5).

It can be seen from the table, that the characters of \(C. cajan\) viz., fugacious stipules, deciduous petals, coarse surface of leaf and absense of strophiole were recessive to those of pollen parent. Likewise, beak of the pod and colour of standard petal of \(C. cajan\) was dominant. Leaf shape was intermediate in the hybrid. Growth of seed parent is erect and that of pollen parent, semi erect-twinning. However, F_1 had erect spreading growth habit. Meiotic studies in female parent revealed 11 bivalents and that in pollen parent 10 II's+2 univalents. Trispecific hybrid showed precocious separation in one of bivalents and was associated with pollen sterility. This may be attributed to the existence of some structural difference in the parental chromosomes. The smooth leaf surface of this hybrid is an indicative of important characteristic from the forage point of view. Also the non shattering nature of the mature pods in this hybrid have shown greater possibility of increased seed harvest. \(C. cajan\) could be crossed with F_1 of \(A. albicans \times A. scarabaeoides\) only when it is involved as seed parent thus showing one way cross compatibility.
Table-5: Cytomorphogentic characters of parents hybrid

(No. of PMC's studied in each case were 40)

<table>
<thead>
<tr>
<th>Characters</th>
<th>C. Cajan</th>
<th>F₁ of A. albicans ( \times ) A. scarabaioides</th>
<th>Trispecific F₁ hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germination</td>
<td>Hypogeal</td>
<td>Hypogeal</td>
<td>Hypogeal</td>
</tr>
<tr>
<td>Growth habit</td>
<td>Erect shrub</td>
<td>Semi erect twiner</td>
<td>Erect-spreading</td>
</tr>
<tr>
<td>Leaf shape</td>
<td>Lanceolate</td>
<td>Obovate</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Leaf surface</td>
<td>Coarse</td>
<td>Smooth</td>
<td>Smooth</td>
</tr>
<tr>
<td>Nature of stipules</td>
<td>Fugacious</td>
<td>Persistent</td>
<td>Persistent</td>
</tr>
<tr>
<td>Nature of petals</td>
<td>Deciduous</td>
<td>Persistent</td>
<td>Peristant</td>
</tr>
<tr>
<td>Colour of standard petal</td>
<td>Yellow</td>
<td>Pale yellow</td>
<td>Yellow</td>
</tr>
<tr>
<td>Hairs on mature pods</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>Nature of mature pods</td>
<td>Non-shattering</td>
<td>Non-shattering</td>
<td>Non-shattering</td>
</tr>
<tr>
<td>Beak of the pods</td>
<td>Prominent</td>
<td>Minute</td>
<td>Minute</td>
</tr>
<tr>
<td>Seeds/pod</td>
<td>2.9</td>
<td>1.62</td>
<td>1.2</td>
</tr>
<tr>
<td>Strophiole</td>
<td>Absent</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>Pollen fertility%</td>
<td>97.0</td>
<td>54.0</td>
<td>47.5</td>
</tr>
<tr>
<td>Chromosomal associations</td>
<td>11-11's</td>
<td>10 II's + 2.0I</td>
<td>7 II's + 8 I's</td>
</tr>
</tbody>
</table>

The F₁ hybrid in the sub-tribe Cajaninae has led to an understanding of considerable genomic homology between Cajanus and Atylosia on one hand and their important role in breeding new plant types on the other.

All the F₁ plants barring one (Pl. no. 3) have shown improvement in their fertility as compared to the F₁ (which had 52.3% fertility). Variabilities in morphogenetic characters arose several biological interests towards understanding the relationship of the three species of Cajaninae on one hand its potentialities in developing new plant types on the other.
Table-6 : Morphogenetic Characters of selected trispecific

$F_2$'s ($C. Cajan \times F_1$ of Cajanifolia $\times A. scarabaiodes$).

<table>
<thead>
<tr>
<th>Characters</th>
<th>$F_2$'s (Plant Nos.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Erect</td>
</tr>
<tr>
<td>Growth</td>
<td></td>
</tr>
<tr>
<td>Leaf shape</td>
<td>Obovate</td>
</tr>
<tr>
<td>Nature of stipules</td>
<td>Fugacious</td>
</tr>
<tr>
<td>Days to flowering</td>
<td>115</td>
</tr>
<tr>
<td>Colour of standard petals</td>
<td>Yellow</td>
</tr>
<tr>
<td>Nature of mature pods</td>
<td>Shattering</td>
</tr>
<tr>
<td>Beak of the pod</td>
<td>Prominent</td>
</tr>
<tr>
<td>Seed pods</td>
<td>1.3</td>
</tr>
<tr>
<td>Strophiole</td>
<td>Present</td>
</tr>
<tr>
<td>Pollen fertility (%)</td>
<td>48.5</td>
</tr>
</tbody>
</table>

Spontaneously originated mutant in Cajan us cajan

A slow growing off-type plant was observed in the population of $C. cajan$ cv. ICP 711 B. The plant attained a height of 90.0 cm as compared to an average height of 180.0 cm of the normal plants. It has less number of leaves (450.0) than the normal ones (780.0). The size of the internodes has been reduced and the leaves have become thick. The number of primary branches was reduced to 1/3 and secondary branches 1/7 of that found in normal plants. The number as well as the size of stomata in this plant was found to be less than the normal plants. These characters showed that this new type of plant has acquired to some extent the habits of a xerophyte, thus indicating plant to withstand moisture stress.

Meiosis revealed chromosome aberrations along with un-stained regions in some of the chromosomes. Other meiotic abnormalities included absence of active pollen movement,
dividing univalents at late anaphase-I, and unequal distribution of chromosomes during anaphase separation. At second meiotic division, particularly at telophase-II, a few micro nuclii were noticed. Pollen grains were of variable size and pollen sterility was high. This could probably be attributed to the meiotic anomalies prevailing in this plant.

5.2. Cytogenetical studies in 

Introduction of new germplasm

Thirteen collections representing twelve species of the genus *Stylosanthes* were procured from CSIRO, Australia. These included, *S. capitata*, *S. fruticosa*, *S. guianensis*, *S. hamata* var. Verano, *S. hamata*, *S. humilis*, *S. leiocarpa*, *S. montevidensis*, *S. scabra*, *S. subsericea*, *S. sundiaca*, *S. sympodialis* and *S. viscosa*. These accessions will be utilized for various cytogenetical studies.

Chromosomal survey

Cytological studies on the genus *Rhynchosia* including the species *R. minima*, *R. sublobata* , *R. densiflora* revealed that the genus like its close relatives *Atylosia* and *Cajanus* is based on a basic chromosome number of \( x = 11 \).

Induced tetraploids

*Macroptelium atropurpureum* cv. *Siratro*

Individuals from tetraploid progeny, with high pollen stainability percentage and reasonably good pod bearing habit were subjected to cytological analysis. All the plants scored showed aneuploid chromosomal constitution of \( 2n = (4x) = 44 \) chromosomes. The meiotic behaviour was typical of induced autotetraploids showing a variable number of quadrivalents and bivalents. Odd chromosomal associations including trivalents and univalents were few in number. The number of quadrivalents per cell varied from a minimum of 4 to a maximum of 10. Number of bivalents varied from 2 to 14, univalents varied from 0 to 2. Since, the size of chromosomes in the genus is very small, complex multivalents were never realized. The maximum number of chiasma per quadrivalent being four. The absence of complex associations resulted into normal disjunction at anaphase.

*Rhynchosia sublobata*

Seeds collected from tetraploid sector of *Cytochimera* of *R. sublobata* were sown, two plants thus raised were confirmed to be induced tetraploids on the basis of morphological
parameters like flower size, pollen stainability and variability in pollen grain size. Since the tetraploids were raised with a view to attempt crosses with established tetraploid of *Atylosia scarabaeoides*, the same could not be attempted due to shy flowering nature of induced polyploids of *Rhynchosia*.

**Sesbania sesban var. Picta and var. Sesban**

*C₃* generation of induced tetraploids of two varieties Picta and Sesban was raised for advancing the generation. Cytological studies revealed no significant alteration from *C₂* generation. Multivalent frequency continued to be high. Disjunctional abnormalities were observed, but the absence of aneuploids in the progeny indicated a strong selection of gametes with balanced chromosomal constitution both quantitatively and qualitatively.

**Advancing generation of autotetraploids of Sesbania aculeata**

*C₄* generation of induced autotetraploids of *Sesbania aculeata* was raised for advancing the generation. Since there is no severe setback in seed production, cytological studies were not carried out since the preceding generation did not show any chromosomal breakdown. Seeds from selected plants with higher pod setting ability were collected for future study on chromosomal stability and/or breakdown of polyploidy.

**Interchange stocks of Sesbania sesban and S. aculeata**

Various interchange stocks of *Sesbania sesban* and *S. aculeata* isolated after gamma irradiation were raised and screened cytologically for identification and isolation of interchange homozygotes. The progeny of a single stock of *Sesbania sesban* showed ring of chain associations of six chromosomes, indicating the involvement of three non homologous pairs of chromosomes. In *Sesbania aculeata* seven different stocks revealed multiple interchange complexes. Since no plant with complete bivalent formation was observed, the existence of normal and/or interchange homozygotes in the progeny was ruled out.

5.4: Cytogenetical studies in range grasses

(M. G. Gupta)

Studies on induced chemical mutagenesis, single plant progeny test, cytogenetica l and pollen studies in *Cenchrus ciliaris* and cytogenetical and pollen studies in *Dichanthium* spp. were conducted.

**Induced mutagenesis**

Seed of *C. ciliaris* IGFRI-3108 was collected from a single plant, treated with 0.25, 0.50, 0.75 and 1.0% EMS for six hours and sown for germination in petridishes as well as
earthen pots along with the control. Percent germination in petridish/pots were 42.0/32.8, 50.0/23.7, 2.0/8.5, 14.0/4.9 and 6.0/4.2, respectively in the control, 0.25, 0.50, 0.75 and 1.0% EMS treatments. Percent seedling survival in petridishes after seven days were 100.0, 84.0, 100.0, 42.9 and 66.7; and in pots after 21 days, it were 96.5, 96.4, 76.7, 53.3 and 0 in the control, 0.25, 0.50, 0.75 and 1.0% EMS treatments, respectively. The surviving seedlings from the various treatments were transplanted in the experimental field. There was no marked difference in morphological, vegetative, and floral characters observed within and among the treatments as compared with the control. However, a marked reduction in pollen survival percentage was observed in 0.75 and 1.0% EMS treatments. Chromosomal complements in all the EMS treatments showed meiotic abnormalities.

Trogeny text

Single plant seeds collected from 51 accession of *C. ciliaris* were sown in the field to study single plant progeny and compared with the parent plant. The progeny plants did not show any significant difference from their respective parent in various morphological, reproductive metricinal inheritance.

Cytogenetical studies

Observations on the meiosis in dividing PMCs were taken in fifteen accessions of *C. ciliaris* and twelve accessions of *Dichanthium* species. The chromosomal associations and ploidy levels were studied. Thirteen accessions—IGFRI-551, 656, 658, 673, 675, 680, 686, 3059, 3078, 3140, 3802, 3813 and V-55 showed 2n=36 as their chromosomal complement at diakinesis. Various chromosomal associations in form of quadri-, tri-, bi- and univalents in these accessions indicated their autotetraploid nature. IGFRI-3107 exhibited aneuploid 2n=(5x-1)=44 and IGFRI-3929 showed 2n (6x)=54 hexaploid, chromosomal complements. Occurrence of varying frequencies of hexa, penta—, quadri—, tri—, bi— and univalents indicated autopolyploid nature of these two accessions also with a basic chromosome number x=9.

*Dichanthium humilis* 19-A and 19-B showed 2n=20, *D. sericium* 22-A, 22-B, 23-A, and 23-B showed 2n=20, *D. supcellatum* IGFRI-2954 showed 2n=20, *D. aristratum* IGFRI-539 and 694 showed 2n=40 and *D. annulatum* IGF-12, 38 and 484 showed 2n=40 as their chromosomal complements with basic chromosome number x=10. Occurrence of various chromosomal associations indicated autotetraploid nature of *D. aristratum* and *D. annulatum* accessions.

Low percent pollen viability on the basis of acetocarmine stainability and wide range in the size of viable pollen grains were commonly observed in all the accessions of *C. ciliaris* and *Dichanthium* species.
DIVISION OF AGRONOMY

AG-3 : AGRICULTURAL/DRYLAND FORAGE AND PASTURE CROPS

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

The treatments comprising five varieties of oat (Kent, OS-6, OS-7, JHO-816 and JHO-810) as pure and mixed 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 were evaluated in split plot design with three replications. All the varieties were harvested 104 days after sowing at flowering stage except JHO-810 which bloomed two weeks earlier.

Oat variety OS-7 producing green fodder, dry matter and crude protein of 430, 100.2, and 5.67 q/ha in sole and 456, 106.6 and 8.01 q/ha in mixed cropping, respectively proved significantly superior to other varieties. Mixed cropping of oat + Senji produced significantly higher forage yields (319 q GM, 92.1 q DM and 7 43 q CP/ha) over pure cropping (361 q GM, 81.6 q DM and 4.69 q CP/ha). Thus, on an average mixed cropping increased the green fodder, dry matter and crude proteins by 8, 12.9 and 58.6%, respectively over sole cropping Senji the companion legume registered highest yields (128 q GM, 31.6 DM and 4.37 q CP/ha) with oat variety JHO-810 and lowest with OS-6 (83 q GM, 23.1 q DM and 3.14 q CP/ha). Application of 90 kg N + 30 kg P<sub>2</sub>O<sub>5</sub>/ha recorded significantly higher forage yields (405 q GM, 93.7 q DM and 6.40 q CP/ha) over 55 kg N + 45 kg P<sub>2</sub>O<sub>5</sub> (345 q GM, 80.3 q DM and 5.7 q CP/ha). The forage yield of Senji was however, more with fertilizer schedule consisting of lower dose of nitrogen and high rate of phosphorus 111 q GM, 28.5 q DM and 3.0 q CP/ha).

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 increased yield and quality of herbage.

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

Three varieties of berseem (Wardan, BL-60 and JHB-137) were evaluated at three levels each of phosphate (0, 60 and 90 kg P<sub>2</sub>O<sub>5</sub>/ha) and sulphur in 3<sup>3</sup> confounding design.
with two replications. The soil of the experimental field was *kabar* (loam) with pH of 7.8 and medium in fertility. In all 5 cuts were obtained in a growth period of 167 days.

Berseem variety JHB-137 recorded significantly higher forage yield (794.4 q GM and 113 q DM/ha). However, the performance of BL-60 was better than Wardan and JHB-137 in the 5th cut. Increasing doses of phosphate and sulphur increased the forage yields and the maximum green (840 q/ha) and dry matter (121.0 q/ha) yields were obtained with 90 kg P₂O₅ and 40 kg Sulphur/ha. Application of 40 kg S/ha improved the crude protein content by 1.5% specially in variety JHB-137.

3. Evaluation of graminaceous kharif forages at different levels of nitrogen

*Sorghum* (M.P. chari, Pioneer-988 and KH-101), maize (Vijay composite and African tall) and *Pennisetum pedicellatum* (IGFRI 43-1) were compared at three nitrogen levels (30, 60 and 90 kg N/ha) in randomised block design with three replications on *parwa* (sandy loam) soil. The crops were sown at their optimum seed rates and harvested at 61 days growth stage except *Pennisetum pedicellatum* which was harvested 3 weeks later.

*Pennisetum pedicellatum* produced significantly higher forage yields (473 q GM and 100.6 q DM/ha) as compared to other forage species. This was followed by hybrid sorghum, Pioneer-988 (386 q GM and 85.5 q/ha DM). On an average *Pennisetum pedicellatum* and Pioneer-988 recorded 85 and 51% higher green forage yield as compared to M. P. chari. Increasing doses of nitrogen significantly increased the forage yields with the result that the highest green forage (408 q/ha) and dry matter (92.2 q/ha) yields were obtained at 90 kg N/ha.

4. Response of *Pennisetum pedicellatum* varieties to varying levels of nitrogen

Three varieties of *Pennisetum pedicellatum* (IGFRI-32-1, 43-1 and 866-1) were compared at four levels of nitrogen (30, 60, 90 & 120 kg N/ha) on medium textured soil in randomised block design with three replicates. Half dose of nitrogen was applied at sowing and the remaining half was topdressed at the 60 days growth stage.

Variety IGFRI 866-1 recorded maximum forage yields (573 q GM and 126.9 q DM/ha) followed by IGFRI 43-1 (541 q GM and 115.6 q DM/ha) but the differences were not significant. Variety IGFRI-43-1, however, maintained longer leaf area duration and exhibited higher crude protein (7.26%) as compared to IGFRI 32-1 (5.96%) and IGFRI 866-1 (6.29%). The oxalic acid ranged from 3.78% for IGFRI 866-1 to 4.22% for IGFRI 43-1. Increasing doses of nitrogen increased the herbage yield and the highest green forage of 680 q/ha was obtained at 120 kg N/ha. Dry matter yield, however, increased significantly only upto
90 kg N/ha (148.2 q/ha). Nitrogen nutrition increased the crude protein in forage but did not show definite trend on oxalate content.

3.2 Cultural management and fertilizer use in forage pasture crop

(A. S. Gill, S. N. Tripathi and K.S. Gangawar)

1. Effect of cutting intervals and stubble heights on forage yield of lucerne (Cv.-244)

The treatments consisting of all combinations of four cutting intervals (3, 4, 5 & 6 weeks) and three stubble heights (4 8 and 12 cm) were evaluated in randomised block design with three replicates. Cutting management treatments were imposed after the 1st common cuttings taken at 58 days after sowing. In all 6, 5, 4 and 3 cuttings were obtained from 3, 4, 5 and 6 weeks cutting intervals, respectively in a growth period of 162 days.

The maximum green forage yield of 554 q/ha was recorded with harvesting at 4 weeks interval. This was statistically at par with 5 weeks interval (531 q/ha) but significantly superior to 3 and 6 weeks intervals. However, maximum dry matter yield was obtained by harvesting at 6 weeks interval (177.8 q/ha) which was statistically at par with 5 weeks cutting interval (166.9 q/ha) but significantly better than 4 (158.9 q/ha) and 3 (97.9 q/ha) weeks cutting intervals. Harvesting the crop at 4-8 cm stubble height was found to produce significantly higher forage yields (522 to 541 q GM and 157.5 to 158.5 q DM/ha) as compared to 12 cm stubble height (463 q GM and 135.1 q DM/ha).

Thus, lucerne should be harvested at 5 weeks interval leaving a stubble height of 4-8 cm for higher forage yields.

2. Effect of intercrops and nitrogen levels on fodder production of winter maize

Five crop treatments involving maize (Vijay composite) in sole stand as well as intercropped in additive series with Batra (Pisum arvens) Tivera (Lathyrus sativus) and oat (cut at 50 days growth stage at 50% flowering) were evaluated at 3 levels of nitrogen (40, 80 and 120 kg N/ha).

Intercropped oat caused significant reduction in dry forage yield of maize as compared to its sole stand. Intercropping Maize with Batra (60.7 q/ha) and Tivera (57.7 q/ha) produced significantly higher dry matter yield over sole crop of maize (52.8 q/ha). The maximum output of crude protein (6.7 q/ha) was, however, obtained by intercropping Maize with Tivera.

Application of 80 and 120 kg N/ha significantly increased the dry matter production
over 40 kg N/ha. Maize intercropped with Batra and Tivera receiving 80 kg N/ha produced additional dry matter of 5.9 and 5.7 q/ha over sole crop of maize fertilized with 120 kg N/ha. The corresponding gain in crude protein yield were 2.6 and 3.4 q/ha.

Thus, winter maize intercropped either with Pisum arvensis or Lathyrus sativus, not only increases the herbage yield and quality but also economizes the use of nitrogen by 40 kg/ha.

3. Studies on mixtures of oat and pea genotypes for higher forage yield

The experiment with eight treatments comprising two varieties each of oat (Kent and JHO-816) and pea (Rachna and tendril type) in pure as well as mixed stands (1:1), was laid out in a randomized block design with three replications. Oat and pea genotypes were sown in lines 25 cm apart, using 100 and 80 kg seed/ha respectively. The crops received 45 kg N + 30 kg P₂O₅/ha as basal fertilizer schedules. Top dressing of 45 kg N/ha was made to cereal component only.

Oat varieties Kent and JHO-816 recorded almost similar forage yield (300 q/ha) in sole cropping. Between pea varieties, Rachna produced higher yields (187 q GM and 38.4 q DM/ha) as compared to tendril type (152 q green and 30.9 q DM/ha). In mixture Kent+tendril type pea recorded maximum green forage yield (309 q/ha) and exhibited higher RCC (3.0) and LER (1.25) values. The highest dry matter yield of 79.4 q/ha was however, obtained with the mixture of JHO-816+Rachna. In combination cropping, oat was found to be a dominant component and pea dominated one.

Therefore, the combination of oat (Kent) + pea (tendril type) appeared to be better from the viewpoint of nutritious herbage production.

4. Studies on relay intercropping in rabi fodder crops

The experiment was taken up with an objective to advance or delay the sowing of pea as intercrop with fodder oat to achieve maximum forage production without jeopardising the yield of individual crop components. The oat was sown on November 3, 1986 and pea was sown on October 27, November 3, and November 10, 1986, both in sole and intercropping. In this way total of 7 treatments were compared in randomized block design with three replications. Under intercropping, oat and pea were sown in 1:1 ratio using 100 and 80 kg
seed/ha respectively in rows 30 cm apart. Fertilizer schedule consisted of 45 kg N+30 kg P₂O₅/ha as basal. Top dressing of 45 kg N/ha was made only to oat crop.

Sowing of oat and pea in alternate rows (1:1) on November 3, gave the highest green (194.3 q/ha) and dry matter (59.7 q/ha) yields. The green (163.7 q/ha) and dry matter (57.1 q/ha) yields of oat and green forage yield of pea (147.1 q/ha) in pure stand were also highest with this date of sowing. However, the highest dry matter yield of pea (37.4 q/ha) was obtained with sowing on October 27.

Between the crops oat was dominant component and pea dominated component. Among the intercropping treatments, oat + pea registered maximum RCC (0.73) and LER (0.97) values when sown on November 3.

5. Effect of plant population on forage yield of hybrid napier IGFRI-3

Treatments consisting of five plant population viz. 10,000, 20,000, 40,000, 80,000 and 160,000 stumps/ha, were laid out in randomised block design with four replications. Nitrogen @ 45 kg/ha was top dressed after each cut. Significantly maximum number of tillers (58) and the highest green fodder yield/tussock (2.3 kg) were obtained with 10,000 plants/ha. However, the highest green fodder (715 q/ha) and crude protein (12.12 q/ha) yields were recorded at 80,000 plants/ha at a spacing of 50 x 25 cm.

6. Effect of foliar spray of Sukshmin-Z on the forage yield of hybrid napier and guinea grass

The treatment consisted of eight combination of two perennial cultivated grasses (hybrid napier, IGFRI-3 and guinea grass, Hamil) and four concentration of Sukshmin-Z (0, 2, 4 and 6 ppm) in RBD with five replications. All the plots were fertilized uniformly with 60 kg N and 20 kg P₂O₅/ha. Nitrogen @ 30 kg/ha as top dressing and foliar spray of Sukshmin-Z as per the treatments was done after each cut. Total three cuts were taken during the period under report.

There was consistently significant increase in forage (928 q green and 309 q DM/ha) and crude protein (19.8 q/ha) yield with an increase in the concentration of Sukshmin-Z up to 4 ppm. Between the grasses, hybrid napier produced significantly higher green fodder (919 q/ha) and dry matter (293 q/ha) as compared to guinea grass (766 q green forage and
268 q DM/ha). Thus foliar spray of 4 ppm Sukshmin-Z (1000 ml of Sukshmin-Z in 500 litres water/ha) appeared to be promising to increase the herbage yield and quality of hybrid napier and guinea grasses.

**Evaluation of Brachiaria species for forage yield**

The experiment with eight treatments consisting of five genotypes of *Brachiaria decumbens* and two of *Brachiaria brizantha* along with a local strain of *Brachiaria decumbens* was repeated in randomised block design with three replications. After each cut 30 kg N/ha was applied and in all 3 cuts were taken.

Significantly higher number of tillers (205) and green fodder yield (1.6 kg/tussock) were obtained with *Brachiaria decumbens* strain No. P. I. 210724 followed by strain No. P. I. 355713. The maximum green fodder yield (616 q/ha) was recorded with strain P. I. 270724, but strain No. P. I. 355713 accumulated the higher dry matter yield of 146 q/ha. The performance of both the strains of *Brachiaria brizantha* was inferior to all the strains of *Brachiaria decumbens*. Therefore, *Brachiaria decumbens* strain No. P. I. 210724 and P. I. 355713 proved to be high yielders.

### 3.3 Cropping patterns for maximum Forage Production

(S. N. Tripathi)

**Performance of Hybrid Napier (IGFRI-3) in association with Leucaena (K-8) under various proportion for forage yield**

(A. S. Gill, S. N. Tripathi and K. S. Gangwar)

This was 2nd year of the experiment. Seven treatment consisting of pure planting of hybrid napier and leucaena along with their combinations in 1 : 1 (alternate rows and mixed in the same row), 2 : 2 (paired rows), 1 : 2 and 2 : 1 row ratio were compared in randomised block design with four replications. Fertilizer schedule consisted of 60 kg N/ha at the beginning of the crop season and 45 kg N/ha after each cut. Three cuts were taken during the period under report.

Planting of hybrid napier and leucaena in paired row system (2:2) not only registered the maximum total green fodder (1112q/ha) and dry matter (282q/ha) yields but also resulted
in higher productivity of both grass and the legume components. The highest RCC (6.02) and LER (1.39) values demonstrated the superiority of planting hybrid napier (dominant component) in paired rows with maximum advantage of their association for realising higher forage production.

3.4 Evaluation and standardization of practices of Dryland Forages including Range and Pasture Grasses

(A. S. Gill and K. S. Gangwar)

Alley cropping studies with *Acacia albida* under rainfed conditions

Treatment combinations comprising five grasses (Guinea, Nandi, *Cenchrus ciliaris*, *Brachiaria decumbens* and Blue panic) and three cutting management (one cut, two cuts and three cuts) were replicated four times in RBD. The trees and grasses were planted in Sept. 1985 and 1986 at spacing of 5m × 5m and 50cm × 50cm, respectively. The grass component received 60 kg N/ha in two equal splits.

Among grasses, the maximum green fodder yield (543 q/ha) was recorded with Nandi grass followed by *Cenchrus* and *Brachiaria*. Guinea and *Brachiaria* were at par between themselves. However, *Brachiaria* produced significantly highest dry matter (158 q/ha) yield over guinea grass (119 q/ha). The highest forage yield (499 q green and 160 q DM/ha) was obtained under three cut system followed by two cut. One cut gave lowest forage yield (415 q green and 139 q DM/ha). The highest crude protein (10 q/ha) was recorded with *Cenchrus ciliaris* and lowest (7.3 q/ha) with guinea grass. Similarly the highest output of crude protein (9.1 q/ha) was obtained with three cut system. Thus Nandi and *Cenchrus* grasses were found to be most productive under tree canopy and yielded better under three cut system of management.

2. Suitability of Weed Control technology for Forage Crops in cropping Systems.

(S. D. Gupta)

Weed management techniques in M. P. chari berseem rotation

Twelve treatment consisting of weedy check, hand weeding and interculture by
weeder cum mulcher (at 2 week, 2 and 4 weeks crop stage), pre-emergence application of atrazine @ 0.75 kg/ha and 0.25 kg/ha followed by one hand weeding at 3 weeks crop stage broadcast and cross sowings of cowpea (25 kg/ha) and sunhemp (15 kg/ha) were evaluated against weed free environment in RBD with four replications.

Results revealed that *Echinochloa colonaum, Dactilocatiniuim aegyptiicuim, Digitaria sanguinisnensis*, among grassy species and *Commelina benghalensis, Didere arvensis, Trithema porchulacastum* among broad leaves were the associated weed flora. Weed control treatments caused 39.7 to 98.5% reduction in weed infestation and produced 1 to 32 q/ha additional dry forage over weedy check (70.5 weeds/m² and 44.3 q/ha DM).

Single hand weeding and interculture at 2 weeks crop stage reduced 35.2 and 42.6% dry weight of weed and elevated dry matter yield of M.P. chari by 1.09 and 4.84 q/ha over weedy check. But two hand weedicings and intercultures at 2 and 4 week crop stage further reduced the weed intensity by 22.7 and 42.5% and caused significant increase in dry matter yields corresponding to 5.3 and 8.8 q/ha over their single application, respectively. The levels of reduction in weed intensity under cowpea and sunhemp were 64.8 and 77.3% respectively. This in turn significantly increased the dry matter yields by 31.8 and 23.6 q/ha over weedy check.

*Atizine* @ 0.75 kg/ha produced 74.1 q/ha dry forage yield and compared very well with weed free environment (74.8 q/ha). This treatment was, however, at par with cowpea as the another crop. *Atrizine* @ 0.25 kg/ha+hand weeding at 3 weeks crop stage yielded 65.8 q/ha dry matter and caused an increase of 15.1 q/ha over hand weeding and 7.9 q/ha over interculture at 2 and 4 weeks crop stage. The corresponding gains due to sunhemp were 17.2 and 10.0 q/ha. This might be due to weed control right from the early phase of crop growth as a result of atrazine+hand weeding treatment on one hand and supressing effect of sunhemp on associated annual weeds on the other.

The smothering effect of cowpea and sunhemp in reducing the weed intensity was of the order of 64.8 and 77.2% respectively over weedy check. Cross sowing of these legumes proved superior over broadcast method. Sowing of cowpea across the rows of M.P. chari produced maximum herbage yield (76.5 q DM/ha) and was therefore reckoned as the best treatment.

3.6: Amelioration of Forage Production with an accent on Nitrogen economy in the existing Cropping Systems

(B. S. Sinsinwar and A. S. Gill)

1. Rice based cropping system involving fodder crops in rabi season
In rabi 1986–87 six fodder crops berseem, lucerne, oat, barley, Senji and mustard along with wheat were evaluated to study the effect of these crops on nitrogen economy of following rice crop. Berseem recorded significantly higher forage yield (337 q/ha) over all other treatments followed by oat (298.7 q/ha). However, dry matter accumulation was significantly higher in barley (75.41 q/ha) as compared to other crops. This was followed by Senji (65.4 q/ha), berseem (65 q/ha) and oat (64.4 q/ha) which were statistically at par among themselves but significantly superior to lucerne (51.2 q/ha).

There was no significant difference in the yield of rice grown after various fodder crops as well as wheat. The maximum grain yield of rice (28.9 q/ha) was however, recorded in the plots grown after barley closely followed by after berseem (28.9 q/ha) and fallow (28.2 q/ha). The differences in the yields of straw were also not significant. However, maximum straw yield (60.5 q/ha) was obtained after lucerne followed by after barley (58.3 q/ha). The direct effect of nitrogen on grain and straw production of rice was significant. The maximum grain (37 q/ha) and straw (77.6 q/ha) yields were recorded with 120 kg N/ha.

2. Rice based cropping system involving important rice varieties

The experiment included five rice varieties (Cross-116, Prasad, Saket, Jaya and T-3) in main plots during kharif 1986 and two fodder crops (berseem and oat) in sub plots in rabi 1986–87. Fodder crops grown after rice variety Prasad produced significantly higher green fodder (271 q/ha) and dry matter (59.6 q/ha) yields. However, the green fodder yield after Saket was statistically at par with this. Between fodder crops, berseem yielded significantly higher green fodder (276 q/ha) over oat (242.5 q/ha) but reverse was the case with respect to dry matter yield.

Wheat based cropping system involving fodder crops in kharif season

During rabi 1986–87 wheat variety HD-1553 grown with recommended fertilizer schedule (120 kg N, 60 kg P2O5 & 50 kg K2O/ha) yielded 36.4 q/ha grain and 59.4 q/ha bhusa. Among main plot treatments of Dolichos, bajra, forage sorghum, maize and grain sorghum, forage sorghum produced significantly higher green fodder (505.8 q/ha) and dry matter (141.7 q/ha) yields. This was followed by bajra both in green (392.3 q/ha) as well as in dry matter (62 q/ha) production.

4. Wheat based cropping system involving important high yielding wheat varieties

In rabi 1986–87 three varieties of wheat (Raj-1555, WH-147 and UP-115) were taken in main plots with 120 kg N, 60 kg P2O5 and 50 kg K2O/ha. Maximum grain yield (38 q/ha) was recorded with variety WH-147 which was significantly higher over Raj-1555 (35.9 q/ha) but it was at par with UP-115 (36 q/ha). The differences in straw yields were however, not significant.
Between sub-plot treatments of two fodder crops (cowpea and sorghum) in kharif, sorghum produced significantly higher green (479.7 q/ha) and dry matter (121.9 q/ha) yields over cowpea (265.8 q/ha green and 36.9 q/ha dry matter) yields.

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-816, 822 and 825) were evaluated at three levels each of Jalshakti (0, 5 and 10 kg/ha) and soil moisture (irrigation at IW/CPE ratio 0.5, 0.75 and 1.0) in 3×3 partial confounding design with 6 blocks each of 9 plots.

Oat varieties did not differ significantly in herbage yield and crude protein production. However, variety JHO-822 produced highest green fodder (353.7 q/ha), dry matter (98.6 q/ha) and crude protein (9.03 q/ha) followed by JHO-825 (337.2 q green, 97.4 q DM and 8.93 q CP/ha). The increasing levels of soil moisture increased the forage yield with the result that significantly highest green (357.9 q/ha) and dry matter (100.7 q/ha) yields were obtained at IW/CPE ratio of 1. The highest CP yield of 9.69 q/ha was also obtained with irrigation at IW/CPE ratio of 1. Application of 5 kg Jalshakti/ha produced highest green fodder (369.8 q/ha), dry matter (97.6 q/ha) and crude protein (9.22 q/ha). The differences were however, significant only for green forage yield. Moreover, Jalshakti at 10 kg/ha did not exhibit beneficial effects.

Variety JHO-822 not only showed greater relative leaf turgidity but also resulted in highest water use efficiency (WUE) of 41.1 kg DM/ha/mm. The applied water use efficiency at IW/CPE ratio of 0.5, 0.75 and 1.0 were 49.7, 38.4 and 33.6 kg DM/ha/mm, respectively. Similarly 5 kg Jalshakti/ha produced the highest relative leaf turgidity as well as water use efficiency (40.8 kg DM/ha/mm).

Therefore, oat variety JHO-822 holds promise and needs to be irrigated at IW/CPE ratio of 1 with 5 kg Jalshakti/ha for realising higher herbage yield and nutrient out turn.

Therefore, oat variety JHO-822 holds promise and needs to be irrigated at IW/CPE ratio of 1 with 5 kg Jalshakti/ha for realising higher herbage yield and nutrient out turn.
2. Response of lucerne to Jalshakti under different soil moisture regimes

The experiment comprising three moisture regimes (IW/CPS ratio of 0.5, 0.75 and 1.0) and five levels of Jalshakti (0, 2.5, 5.0, 7.5 and 10 kg/ha) was repeated in second year in RBD with three replications.

Results revealed that significantly highest green (315.3 q/ha) and dry matter (75.9 q/ha) yields were obtained by scheduling irrigation at IW/CPE ratio of 1.0 as compared to 0.75 (286.7 q green and 67.4 q DM/ha). Increasing the levels of Jalshakti up to 5 kg/ha significantly increased the green forage (357.1 q) and dry matter (84.4 q/ha) yields. Further increases in the level of Jalshakti, however, did not prove its beneficial effects. The water use efficiency was highest at IW/CPE ratio of 0.50 (23.8 kg DM/ha/mm). The water use efficiency at 5 kg Jalshakti was 28.8 kg DM/ha/mm against 16.6 kg DM/ha/mm with control treatment.

3. Performance of graminaceous forage under varying levels of soil moisture and Jalshakti

The significant interaction between moisture regime and Jalshakti revealed that maximum herbage yield of 400.3 q/ha was obtained by scheduling irrigation at IW/CPE ratio of 0.75 with the application of 5 kg Jalshakti/ha.

The growth and herbage productivity of maize, teosinte and M. P. chari were assessed at 3 levels each of soil moisture (25, 50 and 75% ASM) and Jalshakti (0, 5 and 10 kg/ha) in 3 three partial confounding with two replications.

M. P. chari produced significantly highest green forage (367.6 q/ha) and dry matter (78.8 q/ha) over teosinte (249.3 q green and 39.5 q dry matter/ha) and maize (178.1 q green and 22.3 q dry matter/ha) which in turn also differed significantly between them selves. The significant effect of moisture regime was observed up to 75% available soil moisture (ASM) in terms of green forage production (303 q/ha) and only up to 50% ASM in terms of dry matter accumulation (46.5 q/ha). This was associated with plant height which increased significantly by increasing moisture regime from 25% to 50% ASM. Application of 5 kg Jalshakati/ha produced significantly highest green forage (284.1 q/ha) over control treatment (260.4 q/ha). Though the levels of Jalshakti did not cause significant variation in dry matter accumulation but the highest dry matter yield (46.2 q/ha) was obtained at 5 kg/ha.

Therefore, M.P. chari grown with the application of 3 kg Jalshakti at 75% ASM holds greater promise for higher herbage yields.

4. Response of cowpea varieties to Jalshakti and moisture regimes

Three cowpea varieties (NP-3, HFC 42-1 and IGFRI-450) were evaluated under three
Jalshakti (0, 5 and 10 kg/ha) in RBD with 6 replications.

Cowpea variety HFC 42–1 produced significantly higher green forage (215.1 q/ha) and dry matter (34.3 q/ha) as compared to IGFRI 450 and NP 3. Jalshakti at 5 kg/ha produced significantly highest green fodder (190.3 q/ha) over control treatment. The beneficial effect was, however, not observed in terms of dry matter accumulation.

Therefore, cowpea variety HFC 42–1 proved superior over others and the beneficial effect of Jalshakti was observed at 5 kg/ha in terms of green forage yield.

5. Effect of soil moisture variation on forage yield and water use of different sorghum varieties

Four promising sorghum varieties of the Institute (1–3–8–12, 1–2–6–10, D 23–2–1 and JHS 23) were tested under three moisture regimes (25, 50 and 75% ASM) with a view to study their water use pattern in relation to growth behaviour.

The sorghum varieties did not show significant variation in forage yield but the highest green fodder (372.4 q/ha) was obtained with variety JHS 23 followed by D 23–2–1 (348.7 q/ha). The dry matter yield was, however, maximum with variety 1–6–2–10 (81.5 q/ha) followed by 1–3–8–12 (77.6 q/ha). On the other hand, variety JHS-23 exhibited the highest relative leaf turgidity of 76.3%. These observations also lead to conclude that the greater relative leaf turgidity is associated with higher green forage yield.


(N.P. Shukla and Menhi Lal)

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

Three newly developed berseem varieties (Wardan, JB-1 and BL-10) were compared at different irrigation schedules consisting three levels of irrigation water (40, 60, and 80 mm) and soil moisture (0.40, 0.55 and 0.70 atm tension) in 3^3 partial confounding design with 6 blocks each of 9 plots. The depth to water table varied within the range of 20–60 cm upto January and thereafter gradually reduced beyond 2 meters. As a result, the number of irrigations required were two in 0.4 atm tension and one each in 0.55 and 0.70 atm tension treatments. In all 5 cuts were taken for fodder production.

The differences in forage yield of berseem varieties did not reach the level of significance but variety Wardan produced the highest total green forage (876.5 q/ha) and dry
JB-I in dry matter (110.4 q/ha). Variety BL-10 also gave highest green forage yield in last cut. After the water table has receded irrigation at 0.4 atm tension, produced significantly higher green fodder (904.2 q/ha) and dry matter (119.6 q/ha) yields. This treatment proved statistically significant over 0.5 atm in terms of dry matter accumulation but not in terms of fresh fodder yield. The differences in herbage yield between 0.55 and 0.70 atm were however, not significant. The variation in the quantity of irrigation water did not bring significant differences in forage yield. However, the highest green fodder (884.8 q/ha) and dry matter (117.9 q/ha) yields were obtained with 80 mm irrigation at each scheduling.

The highest applied water use efficiency of 141.9 kg DM/ha/mm was recorded with variety Wardan followed by JB-I (138.2 kg DM/ha/mm). Scheduling of irrigation at 0.55 atm tension gave maximum applied water use efficiency of 186.2 kg DM/ha/mm followed by irrigation at 0.7 atm (181.8 kg DM/ha/mm). Application of 40 mm irrigation water gave the highest WUE of 210 kg DM/ha/mm due to major part of the water requirement of crop.

The highest applied water use efficiency of 242.0 kg DM/ha/mm was recorded with variety Wardan followed by JB-I (138.2 kg DM/ha/mm). Scheduling of irrigation at 0.55 atm tension gave maximum applied water use efficiency of 186.2 kg DM/ha/mm followed by irrigation at 0.7 atm (181.8 kg DM/ha/mm). Application of 40 mm irrigation water gave the highest WUE of 210 kg DM/ha/mm due to ground water requirement of crop.

2. Response of forage legume to moisture regimes and phosphate fertility under shallow water table conditions

Three forage legumes (Susuna, Batra and Tiora) were evaluated at three levels each of moisture regime (0.40, 0.55 and 0.70 atm) and phosphate fertility (0, 40 and 80 kg P$_2$O$_5$/ha) in 3$^3$ partial confounding with 6 blocks each of 9 plots. The water table remained within 60 cm depth from surface upto January and gradually receded beyond 2 meter by the end of crop period. As a result only one irrigation was needed for 0.4 and 0.55 atm treatments, whereas the treatment of 0.70 atm did not require any irrigation.

Results showed that decreasing the soil moisture tension for irrigation from 0.70 to 0.55 atm, significantly increased the green fodder yield from 262.9 to 298.8 q/ha and dry matter from 59.0 to 66.4 q/ha. Further decrease in soil moisture tension to 0.4 atm, however, did not influence the herbage yields significantly. Crude protein yield was the highest with irrigation at 0.8 atm tension (11.26 q/ha) which was at par with CP yield at 0.55 atm (10.62 q/ha) but significantly higher than at 0.7 atm (9.43 q/ha). Application of 40 kg P$_2$O$_5$/ha significantly increased the green forage (302.9 q/ha) and dry matter (68.6 q/ha) yields over control treatment (241.4 q green and 58.4 q DM/ha).
Further increase in the level of phosphate to 80 kg P$_2$O$_5$/ha, however, was not beneficial. However, crude protein yield was significantly highest (11.26 q/ha) at 60 kg P$_2$O$_5$/ha as compared to control (9.35 q/ha). Among different crops, *susuna* (*Medicago denticulata*) significantly out yielded (325.5 q/ha), *batra* (289.9 q/ha) and *tiora* (246.6 q/ha) in green forage, which were also statistically different from each other. The dry matter yield was also maximum with *susuna* (70.2 q/ha) which was at par with *batra* (67.9 q/ha) but significantly greater than *tiora* (56.3 q/ha). The crude protein yield followed the trend of dry matter accumulation. Among the interactions, the highest green forage yield (399.6 q/ha) was obtained from *susuna* irrigated at 0.55 atm tension and fertilized with 80 kg P$_2$O$_5$/ha. Similarly *susuna* produced the maximum dry matter (82.1 q/ha) with 80 kg P$_2$O$_5$/ha.

3. **Effect of different moisture regimes and fertility levels on growth and yield of crops in pure and mixed stand**

The response of teosinte, sunhemp and their mixed stand in 2:2 row ratio was studied at 3 moisture regimes (well drained, wetting/drying cycle and above saturation) and 3 soil fertility levels (30+20, 60+40 and 90+60 kg N+P$_2$O$_5$/ha). The crop of cereal received only nitrogen and that of legume only phosphate as per the treatments.

The green forage yield of teosinte in pure stand was the highest (282.1 q/ha) but at par with mixed stand of teosinte+sunhemp (272.5 q/ha). The sole crop of sunhemp produced significantly lower forage (236.1 q/ha). However, sunhemp accumulated the highest dry matter (60.3 q/ha) which did not differ significantly from mixed stand of teosinte+sunhemp. Teosinte on the other hand produced significantly lower dry matter (42.2 q/ha). This kind of trend was due to higher dry matter percentage of sunhemp. The maximum green forage (289.9 q/ha) and dry matter (57.4 q/ha) yields were obtained under well drained conditions. However, the differences were significant only for green matter yield. Continuous saturation caused greater yield reduction producing 238.2 q/ha green forage and 57.5 q/ha dry matter. There was linear increase in green and dry forage yields due to increasing levels of soil fertility with the result that 90 kg N+60 kg P$_2$O$_5$/ha produced highest herbage yield.

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

(N. P. Shukla and Menhi Lal)

*Agronomic evaluation of Jalshakti with pasture legumes in red gravelly soil*

Four perennial legumes (siratro, stylo, desmenthus and desmodium) were evaluated
for their forage productivity under four levels of Jalshakti (0, 2.5, 5.0 and 7.5 kg/ha) in RBD with 3 replications.

Stylo yielded significantly higher green fodder (275 q/ha) and dry matter (115 q/ha) over siratro (163.7 q green and 46.2 q dry matter/ha). The dry matter yields of siratro (46.2 q/ha), desmenthus (52.7 q/ha) and desmodium (52.6 q/ha) were, however, at par.

Jalshakti at 5 kg/ha produced significantly maximum green forage (197 q/ha) and dry matter (73.1 q/ha) yields over control (149.5 q green and 61.4 q DM/ha). The differences in forage yields of other doses, however, did not reach the level of significance.

AG-6 : AGRO-FORAGE FORESTRY PRODUCTION SYSTEM

6.2 Investigation on the Integration of Appropriate Fodder Crops in Food/Cash Crop Rotations and as Intercrops.

(A. S. Gill and K. S. Gangwar)

Horti-pastoral studies with guava, custard apple and aonla

The investigations were taken up with a view to raise fodder as well as food crops in the inter row spaces of important fruit species of the region such as guava, custard apple and aonla planted at 4m × 4m spacing in 1985-86.

Guava (Psidium guajava L.) :

The understorey crops included hybrid napier, guinea grass and Nandi grass at 50cm × 50cm spacing in pure stand and intercropped with cowpea in summer and berseem in winter. Grasses received 60 kg N+20 kg P₂O₅/ha as basal dose and 30kg N/ha after each cutting. The fertilizer schedule to intercrops consisted of 20 kg N+30 kg P₂O₅/ha for cowpea 20 kg N+80kg P₂O₅/ha for berseem.

The experimental result showed that hybrid napier + cowpea gave significantly higher green fodder yield (650 q/ha) followed by guinea grass+cowpea (575 q/ha). Pure crop of hybrid napier however, recorded higher dry matter yield (159q/ha). Guinea grass+cowpea also produced higher crude protein (12.4 q/ha) which was at par with pure cowpea (12.0 q/ha) and hybrid napier+cowpea (11.7 q/ha). Thus, the combination of hybrid napier + cowpea hold promise for higher herbage production in the inter row spaces of guava plantations.

Custard apple (Annona squamosa)

Five important rotations viz. maize (fodder)-wheat-sorghum (fodder), maize (fodder)
sorghum (fodder) and stylo round the year were simultaneously evaluated under the canopy of custard apple and Aonla. Maize (Vijay composite), wheat (Raj 1555) and sorghum (PC-6) were fertilized with 60 kg N+30kg P_2O_5/ha, 120 kg N+60kg P_2O_5+60 kg K_2O/ha and 90 kg N/ha, respectively. The fertilizer schedule for legume component included 30 kg N+50 kg P_2O_5/ha for cowpea (Russian giant) and 20 kg N+50 kg P_2O_5/ha to each grain (C-850) and stylo (Stylosanthes hamata).

Wheat and gram yielded 38.9 and 21.4 q/ha grain and 19 q/ha straw. The yields of these crops were significantly higher in cowpea-wheat-sorghum and maize-gram-sorghum rotations respectively. Sorghum produced significantly higher green fodder (404 q/ha) in cowpea-gram-sorghum rotation, however, maximum crude protein (15.5 q/ha) was obtained in the rotation where stylo was grown throughout the year.

/ onla (Embica officinalis)

In this system, maize-wheat-sorghum and maize-gram-sorghum rotations gave significantly higher grain yield of wheat (59.6 q/ha) and gram (15.2 q/ha), respectively. The straw yields of 62 and 13.9 q/ha were however, more in rotations where cowpea preceded these crops. The highest green fodder (531 q/ha) and dry matter (154 q/ha) yields of sorghum were obtained in maize-gram-sorghum rotation. However, crude protein yield (18.4 q/ha) was significantly greater with stylo grown round the year.

In general higher forage and grain yields were obtained with maize-wheat-sorghum and cowpea-wheat-sorghum rotations in the interrow spaces of custard apple. Under Aonla canopy the yields were low due to vigorous growth which intercepted about 75% of the total radiation against only 30% by custarded apple plantation. This indicates that understorey crops can do better under custard apple as compared to Aonla plantation.

2. Alley cropping studies with Leucaena leucocephala

The experiment was conducted with a view to obtain higher green fodder and nutrient output per unit area. Treatments comprising three wheat varieties (Raj 1555, WH-147 and UP 115) in wheat-sorghum-groundnut rotation were evaluated with and without leucaena. Pure stand of leucaena planted at 2m \times 1m spacing in 1985 was also included for comparison. The fertilizer schedule consisted of 60 kg N+60 kg P_2O_5/ha for wheat (all varieties), 45 kg/ha for sorghum (PC-6) and 20 kg N+30kg P_2O_5/ha for groundnut. The minimum reduction in yield (2.3 q/ha) occurred in wheat variety Raj 1555 which produced highest grain yield with (40.2q/ha) & without (42.5q/ha)leucaena. The performance of sorghum was better under sole cropping (347 q green and 103 q DM/ha) than under intercropping. The green forage yield of leucaena under old stand was 558 q/ha and under intercropping 432q/ha. The highest crude protein yield (21.4q/ha) was recorded with pure planting of leucaena. Therefore under leucaena alleys wheat-sorghum-groundnut could successfully be adopted to produce forage as well as food to increase the vertical productivity of land.
1.2 Studies on the establishment and management of *Stylosanthes*, *Cenchrus* and *Dichanthium* based pasture for their sustained productivity

(P. Rai)

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

Studies were continued for the third year on the four range grasses viz. *Dichanthium annulatum*, *Cenchrus ciliaris*, *Cenchrus setigerus* and *C. ciliaris* × *C. setigerus* hybrid and a legume, *Stylosanthes hamata* in pure and in mixtures to know the effect of cultural and fertilizer treatments on the productivity of these pastures. Two cuttings were taken in all the grasses, legumes and grass-legume mixture except *Dichanthium* where three cuttings were taken. The results are summarized below:

Forage Production

**Grasses**: Green and dry forage yields significantly increased with the application of fertilizer (60 kg N+30 kg P₂O₅/ha) and interculture+fertilizer in all the grasses (Table 7). Due to interculture also, the green and dry forage yields increased as compared to control but the increase was non significant. In all the grasses, green and dry forage yields with fertilizer application and interculture+fertilizer were not statistically significant.

Among the four grasses, the mean maximum green (27.3 t/ha) and dry (8.5 t/ha) forage yields were obtained in *C. Ciliaris* and *D. annulatum*. While the minimum green (21.5 t/ha) and dry (7.0 t/ha) forage yields were recorded in *Dichanthium* and *Cenchrus* hybrid.

**Legume**: The green and dry forage yields of *S. hamata* did not differ significantly in various treatments. However, the maximum green (10.6 t/ha) and dry (3.9 t/ha) forage yields were recorded with the application of 60 kg P₂O₅/ha followed by 60 kg P₂O₅+20 kg S/ha.

**Grass-Legume Mixture**: The green and dry forage yields increased significantly with the application of 30 kg N+60 kg P₂O₅/ha and interculture+fertilizer over control in all the
<table>
<thead>
<tr>
<th>Treatment</th>
<th>C. ciliaris</th>
<th>C. setigerus</th>
<th>C. ciliaris x C. setigerus hybrid</th>
<th>D. annulatum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Green</td>
<td>Dry</td>
<td>Green</td>
<td>Dry</td>
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<td>Control</td>
<td>22.2</td>
<td>6.3</td>
<td>14.4</td>
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<td>6.8</td>
<td>20.1</td>
<td>6.5</td>
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<tr>
<td>60 kg N + 30kg P₂O₅/ha</td>
<td>31.6</td>
<td>9.9</td>
<td>29.3</td>
<td>8.7</td>
</tr>
<tr>
<td>Interculture + 60 kg N + 30 kg P₂O₅/ha</td>
<td>31.5</td>
<td>10.0</td>
<td>29.0</td>
<td>8.6</td>
</tr>
<tr>
<td>C. D. at 5%</td>
<td>2.4</td>
<td>1.4</td>
<td>2.3</td>
<td>0.8</td>
</tr>
<tr>
<td>Mean</td>
<td>27.3</td>
<td>8.2</td>
<td>24.5</td>
<td>7.5</td>
</tr>
</tbody>
</table>
The maximum dry matter yield of 9.3 t/ha (7.5 t from grass + 1.8 t from legume) 10.0 t/ha (10.1 t from grass + 0.8 t from legume), 8.2 t/ha (7.0 t from grass + 1.2 t from legume) and 9.8 t/ha (9.0 t from grass + 0.8 t from legume) was obtained with C. setigerus C. ciliaris, Cenchrus hybrid and D. annulatum grown in mixture with S. hamata, respectively with the treatment consisting of interculture + fertilizer application (30 kg N + 60 kg P₂O₅/ha).

On an average, the maximum mixed green forage yield was recorded in C. ciliaris (21.5 t/ha) followed by C. setigerus (21.3 t/ha) and the minimum in Dichanthium annulatum (17.0 t/ha) while the maximum dry matter yield (8.5 t/ha) was maintained with C. ciliaris but followed by D. annulatum (7.9 t/ha) and the minimum was recorded in Cenchrus hybrid (6.8 t/ha). The higher dry matter yield in Dichanthium was due to higher dry matter percentage as compared to Cenchrus species.

Persistency

Data on plant population of grasses and legume recorded in pure and mixtures at the time of first cutting did not reveal much difference in the plant populations of the grasses due to different management practices either grown in pure stand or in mixture.

Out of the four grasses, D. annulatum showed higher survival (99.4%) in mixed stand and D. annulatum and Cenchrus hybrid were at par in case of pure stand (99.3 and 99.6%, respectively). C. setigerus gave the lowest survival when grown in pure stand (93.8%) or in mixtures (87.0%). The plant population of S. hamata was higher in the control plot. On an average, the highest population (103.5 plant/m²) was recorded in mixture of C. setigerus followed by D. annulatum (90 plants/m²) and the minimum in C. ciliaris (71.8 plants/m²).

Crude Protein Content

Plant samples of two cuttings were analysed separately and it was observed that crude protein content increased with application of fertilizers in both cuttings in all the grass-legume mixtures. However, crude protein recorded in November cutting was slightly lower than September one in all the grasses and grass-legume mixture except in Dichanthium pure and Stylosanthes grown in mixture with C. setigerus where the crude protein was same. The average of two cuts showed the maximum crude protein of 7.4, 7.1, 7.9, and 7.4 per cent in C. ciliaris, C. setigerus, Cenchrus hybrid and D. annulatum respectively in the treatment consisting of interculture + application of 60 kg N + 30kg P₂O₅/ha when grown in pure stand. When these grasses were grown in mixture with S. hamata similar trend was observed, case of S. hamata maximum crude protein of 13.3, 13.2, 13.7, and 13.3 per cent was observed.
when grown with *C. ciliaris*, *Cenchrus* hybrid, *C. setigerus* and *D. annulatum*, respectively with application of 60 kg P₂O₅, 30 kg N/ha.

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

(P. Rai and Vinod Shankar)

This experiment aimed at standardizing the optimum proportion of seed mixtures of *Cenchrus ciliaris* and *Stylosanthes hamata* for better establishment and higher production. Four seed mixtures in the proportion of 100 : 100 (4 kg/ha *C. ciliaris* + 6 kg/ha *S. hamata*, it is recommended seed rate), 50 : 50 (2 kg/ha grass + 3 kg/ha legume), 66.6 : 33.3 (2.6 kg/ha grass + 2 kg/ha legume) and 33.3 : 66.6 (1.3 kg/ha grass + 4 kg/ha legume) were evaluated. Area for each treatment was 0.4 ha. Basal dose of 20 kg P₂O₅ and 20 kg N/ha was given after two harrowings and mixed in soil during the third harrowing. Seed were broadcasted on 11th July, 1987 and a shrub branch was run over the whole area to cover the seeds with a thin layer of soil. Data on plant population and forage yield were recorded on 18.9.87 and 18.10.87, respectively through quadrats. Fifty quadrates (50 cm²) were taken for plant population and 20 quadrates (100 cm²) for forage production.

Results on the establishment showed that the maximum plant population (4,56,000 plants/ha) was recorded when sowing was done in the proportion of 100 : 100 which was significantly higher than rest of the seed mixtures followed by 50 : 50 proportion (2,80,000). In all the proportions the legume population was higher than the grass. Data on forage yield was recorded separately for *C. ciliaris*, *S. hamata*, other grasses and forbs. The maximum dry matter yield of 5.46 t/ha (2.50 t from *S. hamata*, 0.67 t from *C. ciliaris*, 1.18 t from other grasses and 0.56 t/ha from forbs) was obtained in the mixture of 50 : 50 proportion followed by 100 : 100 proportion (4.42 t/ha). Data on plant vigour showed that the highest plant height of grass and legume was recorded in the seed mixture of 66.6 : 33.3 and 100 : 100 proportion, respectively. While the maximum number of the tillers/plant was recorded in the 50:50 proportion. There was not much variation in the primary and secondary branch numbers of *S. hamata* while tertiary branch number showed variation. The maximum number of tertiary branch was recorded (55) in 33.3:66.6 seed mixture followed by 50:50 proportion (51.4). Thus, seed mixture in the proportion of 50:50 is the optimum for higher production.

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

(P. Rai and M. R. Pahwa)

This experiment was conducted to know 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 (Stylosanthes hamata, Cajanus cajan, Lablab purpureus and Clitoria ternatea) making a total of 15 treatments on the productivity of C. setigerus. The soil of the experimental field was sandy loam in texture, normal in pH with organic carbon (0.33%). The available N, P and K were 224.4 kg/ha, 9.5 kg/ha and 231 kg/ha, respectively. The initial Azospirillum and Azotobacter counts of the soil were $0.20 \times 10^2$ cells/g and $6.1 \times 10^3$ g cells of soil, respectively. Two cuttings (6.10.87 and 24.11.87) were taken from grass and only one cutting from the legumes.

Intercropping of Cajanus cajan was more beneficial followed by Lablab purpureus as compared to all other 13 treatment. Due to intercropping of Cajanus cajan the production of dry forage, grain and fuel were 3.95, 0.41 and 1.36 t/ha, respectively. The mixed forage yield obtained with intercropping of Cajanus cajan was even slightly higher than that at 40 kg N/ha either applied through urea or FYM. Application of Azospirillum alone did not show beneficial effect on the forage yield.

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

(K. P. Niranjan and K. C. Kanodia)

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$_2$O$_5$/ha) was laid out in the randomised block design with three replications. Fertilizers were applied on 7.7.87 and only one cutting was taken on 30.10.87.

Application of different levels of nitrogen significantly increased the dry matter production. The dry matter yield increased by 65.6, 122.0 and 158.8% over control due to application of 15, 30 and 45 kg N/ha, respectively. Application of phosphorus also gave significant response on forage yield of this grass. The maximum dry forage yield (4.94 t/ha) was obtained with the application of 30 kg P$_2$O$_5$/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$_2$O$_5$/ha, grass+legume (1:1 ratio) and grass+legume+30 kg P$_2$O$_5$/ha,
laid out in randomised block design with four replication. After gap filling, the fertilizers were applied on 22.7.87 and only one cutting was taken on 30.10.87. The maximum dry forage yield (9.4 t/ha) was recorded with *S. hamata* fertilized with 30 kg P₂O₅/ha which was significantly higher than the other treatments. The minimum forage yield (2.78 t/ha) was noted in the control (grass alone).

*Brachiaria decumbens*

Similar studies were also conducted on *B. decumbens* and results revealed that the maximum dry matter yield of 11.1 t/ha (3.7 t from grass + 7.4 t from legume) was recorded with grass + legume fertilized with 30 kg P₂O₅/ha followed by (11.0 t/ha) from *S. hamata* plus 30 kg P₂O₅/ha. The minimum dry matter yield (5.8 t/ha) was recorded with grass alone.

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

2.1: Investigations on the introduction of legumes for improvement of natural grasslands

1. Studies on the effect of time and method of sowing of legume, *Stylosanthes hamata* introduced in natural grasslands

(K. C. Kanodia, K. P. Niranjan and S. S. Parihar)

Studies were repeated during the third year with three techniques of sowing (broadcasting, dibbling and line sowing) in combination with four dates of sowing (May end, mid June, June end and mid July) on the establishment and yield of *Stylosanthes hamata* introduced in a natural grassland. The results are summarized below:

Effect of sowing technique

The lines sowing gave significantly higher plant population in comparison to broadcasting. There was no significant difference in the plant population in dibbling and broadcasting. Maximum plant population 4,22,500 plants/ha was recorded with line sowing followed by broadcasting 3,91,667 plants/ha and the minimum in dibbling.

Significant difference in dry matter yield was also observed with line sowing in comparison to broadcasting and dibbling. No significant difference in the dry matter yield was observed in later two treatments.

Effect of time of sowing

There was a significant correlation among the time of sowing and the plant
population. The plant population of the introduced legume showed linearly decreasing trend with the delay in sowing time. The highest plant population (5,56,333 plants/ha) was recorded in the plots sown in May end, followed by (3,60,000 plants/ha) in plots sown in mid June and June end (31,4445 plants/ha) and minimum (1,26,667) in the plots sown in the middle of July.

Significant differences in forage yield with regard to different time of sowing was also observed. Sowing in the end of May resulted in significantly higher yield (2.73 q/ha) in comparison to other sowing times. However, there was no difference in dry matter yield in mid June (1.58 q/ha) and June end (1.34 q/ha) sowings. The lowest yield of 0.63 q/ha was obtained from the mid July sowing.

2.3 Studies on the performance of Stylosanthes hamata in natural grassland under different management practices

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

With a view to improve the Sehima dominated natural grasslands field studies were repeated for the second year. Six treatments comprised of T1-Control, T2-Stylo + 20 kg P2O5/ha broadcast, T3-Furrows at 1 m spacing, T4-Stylo broadcast, T5-Stylo sown in furrows 1 m apart and T6-Stylo with 20kg P2O5/ha in furrows 1 m apart. The percentage composition (22.3%) with 6800 plants/ha of Stylo was the highest (Table-8) under broadcast treatment (T2), while in the furrowed plots without phosphorus (T5) it was 18.75% with 45000 plant population/ha indicating thereby that this exotic legume can also be established without phosphorus fertilizer.

A total of 47.91 q/ha biomass was harvested in the treatment T6 with forrows P2O5 and Stylo. A total of 23.97 q/ha biomass was harvested in T1 (control) Table-9. Thus the overall productivity of Sehima grassland improved significantly primarily due to furrowing coupled with Stylo introduction and the yield of Sehima was also directly related to its higher plant population.

4.5-2 Ecological studies of different grassland communities of semi-arid regions for increasing plant and animal productivity – Iseilema community

(B. K. Trivedi and P. Kumar)

This study involved four treatments viz; grazing only (T-1), defoliation only (T-3), defoliation + fertilizers (T-4). The results are summarised below :-

The total standing biomass ranged from 4.48 to 6.28 t/ha in treatment T-3 and
Table-8: Percentage botanical composition of different treatment plots.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>S.shima</th>
<th>Other grasses</th>
<th>Stylo</th>
<th>Other legumes</th>
<th>Forbs</th>
<th>Bushes</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-1</td>
<td>12.8</td>
<td>59.2</td>
<td>—</td>
<td>12.5</td>
<td>15.4</td>
<td>—</td>
</tr>
<tr>
<td>T-2</td>
<td>12.6</td>
<td>50.1</td>
<td>8.6</td>
<td>1.26</td>
<td>17.2</td>
<td>—</td>
</tr>
<tr>
<td>T-3</td>
<td>17.4</td>
<td>46.6</td>
<td>—</td>
<td>16.6</td>
<td>19.5</td>
<td>—</td>
</tr>
<tr>
<td>T-4</td>
<td>12.8</td>
<td>52.2</td>
<td>7.5</td>
<td>13.5</td>
<td>12.8</td>
<td>0.3</td>
</tr>
<tr>
<td>T-5</td>
<td>13.5</td>
<td>33.1</td>
<td>18.8</td>
<td>15.4</td>
<td>19.3</td>
<td>—</td>
</tr>
<tr>
<td>T-6</td>
<td>11.7</td>
<td>35.1</td>
<td>22.3</td>
<td>15.2</td>
<td>13.9</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Table-9: Dry forage yield (q/ha) of different components.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>S.shima</th>
<th>Stylo</th>
<th>Other Associates</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-1</td>
<td>23.547</td>
<td>—</td>
<td>0.425</td>
<td>23.970</td>
</tr>
<tr>
<td>T-2</td>
<td>25.014</td>
<td>0.530</td>
<td>1.847</td>
<td>27.391</td>
</tr>
<tr>
<td>T-3</td>
<td>25.720</td>
<td>—</td>
<td>1.908</td>
<td>27.628</td>
</tr>
<tr>
<td>T-4</td>
<td>25.134</td>
<td>0.269</td>
<td>1.755</td>
<td>17.158</td>
</tr>
<tr>
<td>T-5</td>
<td>26.788</td>
<td>0.248</td>
<td>0.564</td>
<td>29.580</td>
</tr>
<tr>
<td>T-6</td>
<td>45.788</td>
<td>0.577</td>
<td>1.856</td>
<td>47.911</td>
</tr>
</tbody>
</table>
Eight calves weighing 160–200 kg were introduced for grazing which was continued for 75 days. At the end of grazing period there was a net average gain of 430 g/head/day in their body weight. The hay was prepared from defoliated treatments and was fed to these animals under stall feeding. The trial is in progress.

GM 4.6 Autecology and Growth Behaviour Studies in Different Range Grass

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

- Effect of nitrogen and growth period on the productivity of *Chrysopogon fulvus* pasture under rained condition

Studies were continued for the 7th year to know the effect of 3 levels of N (0, 45 and 90 kg/ha) and 4 growth periods (15, 30, 45 and 60 days) as well as aging of the sward on the productivity of *C. fulvus*. Results showed that the dry matter yield was significantly influenced by the application of nitrogen. However, increase in levels of N from 45 to 90 kg/ha, forage yield did not increase significantly. The maximum forage yield of 3.13 t/ha was recorded at 60 days growth which was significantly higher than all the growth periods. When the production of 1987 was compared with the yield of 1986, it was observed that the yield decreased at all the growth periods which may be attributed to both lower rainfall in 1987 as well as to the sward binding.

2 Seed germination studied on *Chrysopogon fulvus*

The seed in *Chrysopogon fulvus* is a 'trial' consisting of three spikelets: one sessile and hermaphrodite possessing the grain (caryopsis) with two pedicellate and sterile spikelets on the either side. Therefore, two kinds of germination studies were conducted (i) with intact seed (dispersal unit), (ii) and with dehusked seeds. The results are summarized below.

Primary Dormancy and Reduction of Dormancy by Serification Treatments

Freshly collected seeds exhibit primary dormancy of about three months for after-ripening. Dormancy of the freshly harvested spikelets can be reduced by various treatments viz. pre-chilling; heat KNO₃, ethanol and GA. Maximum germination (20.7%) was recorded with GA (gibberellic acid) followed by ethanol (10%) and KNO₃ (potassium nitrate)(7.0%).
Enhanced germination of non-dormant spikelets stored for 9 months was also observed by various treatments and maximum germination (45.33) was found with gibberellic acid followed by pre-chilling (38.66%), ethanol (38.66%) and potassium nitrate (38.0%).

**Effect of Storage and Removal of Glumes on Germination**

The seeds come out of primary dormancy after a storage of about 3 months and therefore, percentage germination increases with the storage. The percentage germination increased from 6.33% at three months of storage to 23.33% at six months of storage. Further increase in germination percentage upto 12 months of storage (40.66%) was noticed. There was no significant differences in percentage germination at 12 and 15 months of storage. Decline in percentage germination of spikelets was observed after 18 months.

In dehusked seeds, there was no significant variations in percentage germination in 6 to 15 months old seeds.

Removal of caryopsis (seeds) the enclosing glumes had an enhanced effect of percentage germination indicating that inhibitory effect is due to glumes and phenolics present in the glumes. However, the viability of dehusked seeds was lost within 9 months of their storage, suggesting that seed enclosing glumes together with phenolics are vitally important for preserving the viability of seeds for a longer period of time under natural condition.

3 **Rate of Germination**

The germination of spikelets was uneven and it extended for longer period as compared to seeds. The germination curve was sigmoidal and positively skewed. Germination of spikelets from the next day of sowing (3.33%) and continued upto 11th day (32.0%). In case of seeds, 42.% germination was observed after 24 hrs of sowing, which increased to 59.66% on 3rd day and 62.0% and 63.0% on 5th day. No seed germination was recorded beyond 5th day. Removal of glumes led to even and comparatively quick germination in seeds which evidently confirmed the inhibitory effect of glumes as well as exogenous phenolics present in the husk.

**Bio-assay Studies and Characterisation of Germination Inhibitors**

Since the removal of glumes had an enhanced effect of germination, bioassay studies were conducted with the methanolic extract of the dispersal unit using the seeds of *C. fulves* and two test species. Bio-assay studies confirmed the inhibitory effect methanolics extract on *C. fulves* as well as on two test species.

Owing to inhibitory effect of methanolic extract of dispersal units, isolation and characterisation of germination inhibitors was conducted by the combined use of chromatography, absorption spectroscopy and colour reactions. The study revealed the presence of phenolic acids viz, P-hydroxybenzoic, vanallic and syringic acid, hydroxycinnamic acid viz, Caffeic ferulic and p-coumaric acids and flavonoids viz, glycoside of quercetion and kaempferol.
DIVISION OF AGROSILVIPASTURE

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 of Silvi-4

In this 3rd year of growth a shift in the peak values at wider spacings was observed in general. At the end of 1.5 years after planting the peak growth in height (5.5 mm) was obtained at 1×1m which continued till the end of 2.5 years with a seasonal shift during June. In case of CD a gradual shift was evident (Table 10). It shifted from 1.5×1.25 to 1.5×1.5 and 2×2m indicating competitive stress at closer spacings. The DBH also showed similar trend indicating faster growth increment at wider spacing.

Table 10: Annual increment per tree in *Leucaena leucocephala* of different ages (year).

<table>
<thead>
<tr>
<th>Attributes</th>
<th>3.5–4.5</th>
<th>4.5–5.5</th>
<th>Years</th>
<th>5.5–6.5</th>
<th>6.5–7.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hight (m)</td>
<td>0.84</td>
<td>1.10</td>
<td>1.88</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td>CD (cm)</td>
<td>0.45</td>
<td>1.25</td>
<td>2.53</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>DBH (cm)</td>
<td>0.62</td>
<td>0.95</td>
<td>1.95</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td>Bole wt. (kg.)</td>
<td>3.21</td>
<td>10.22</td>
<td>13.74</td>
<td>3.21</td>
<td></td>
</tr>
<tr>
<td>Branch wt. (kg)</td>
<td>0.85</td>
<td>2.52</td>
<td>3.17</td>
<td>-1.22</td>
<td></td>
</tr>
<tr>
<td>Leaf wt. (kg)</td>
<td>0.14</td>
<td>1.22</td>
<td>0.62</td>
<td>-0.17</td>
<td></td>
</tr>
</tbody>
</table>

Growth and biomass increment in relation to time

The data from felling of plantations of different age groups indicated that peak annual increments in a plantation at 1×1m spacing was obtained between 5.5–6.5
years age followed by increment between 4.5–5.5 years. Afters 6.5 years the increment was very poor and in branches and leaf biomass it showed negative growth due to shedding of dry branches and leaf. Thus 10.2 and 13.7 kg/tree was added to the bole between 4.5–5.5 and 5–6.5 years age, respectively.

Survival and growth compared to Eucalyptus in shelter belts

On river side slope, a shelter belt was planted at 2x2m spacing by Leucaena and Eucalyptus under 3 planting arrangements. After 6 months the survival and growth data revealed (Table II) 10% more survival of Leucaena compared to Eucalyptus. In Eucalyptus peak survival of 84.7% was obtained under monocrop followed by alternate line arrangement. The alternate plant arrangement gave only 76.7% survival. In Leucaena it was uniform 93.7–98%. The height and diameter growth were more in Eucalyptus compared to Leucaena. At this early stage the effect of plant arrangements was not so much pronounced.

1.2 Autecological studies on Albizia spp. and Dichrostachys cinerea.

(M. M. Roy)

Germination of insect affected seeds in A. lebbek:

41.2% seeds of A. lebbek, collected from IGFRI farm during 1986–87 were found to be predated ones. Moderately affected seeds (12.2%) gave almost equal germination (76.7%) as the healthy ones. In controlled conditions (30±2°C) GRI values of moderately affected seeds were higher by 19.2%. However, SVI values were lower by 47.5%. Germination of highly affected seeds (28.9%) was less than 10%.

Salt tolerance in relation to germination and initial seeding vigour in A. falcataria

Germination at 15th day count was found to be in the range of 70 to 76% up to 0.15-M NaCl solution. There was no significant difference in GRI and SVI values within this range. Up to 0.35-M concentration, germination was maintained at 50%. However the values of GRI and SVI decreased by 35.7% and 30.1%, respectively. Beyond 0.35-M concentration, the total germination reduced drastically.

Seedling emergence and establishment of four species of Albizia and D. cinerea under subabul and shisham canopies

In a nursery study during March–April, under open sunlight (1.93×10^3 Wm^-2) and partial, dense and very dense canopies of subabul (2.94×10^2 to 1.54×10^2 u Es^-1 m^-2) and shisham (1.98×10^2 u Es^-1 m^-2) trees, maximum emergence after one-month was recorded in A. falcataria (78%) under dense canopy of subabul. It was followed by D. cinerea (76%)
under partial canopy of subabul, *A. lebbek* (53%) and *A. procera* (43%) under partial canopy of shisham and *A. amara* (26%) under dense shade of shisham. However, maximum establishment after 45 days, found in *D. cinerea* (70%) under dense canopy of shisham followed by *A. falcataria* (59%) under dense shade of subabul, *A. lebbek* (50%), *A. procera* (35%) and *A. amara* (19%) under partial canopy of shisham.

**Seedling survival of 4 species of *Albizia* and *D. cinerea* on shifting from nursery beds to polythene containers**

In a nursery study on shifting 45-days old seedlings, maximum survival after 120 day recorded in *D. cinerea* (78%) followed by *A. lebbek* (68%), *A. amara* (67%), *A. procera* (43%) and *A. falcataria* (12%). Highest seedling biomass was attained by *A. lebbek* (3.86 g) followed by *D. cinerea* (3.70 g), *A. procera* (3.69 g), *A. falcataria* (3.4 g) and *A. amara* (0.02 g).

**Sapling establishment and growth of 4 species of *Albizia* and *D. cinerea* in field**

After transplanting of 4-month old saplings of these species in 30 cm³ pits in a natural grassland area dominated by *Dichanthium annulatum*, *Sesihma nervosum*, *Chrysopogon fulvus* and *Iseilema laxum*, peak survival and growth were exhibited by *D. cinerea* and *A. amara* respectively (Table-12). During September *A. falcataria* exhibited significantly low survival at 5% probability level. By December all plants of this species died. During December *A. procera* exhibited significantly low survival and growth in height and collar diameter at 5% probability level. In this period *A. lebbek* also showed significantly low height growth.

### 1.3 Autecological studies on exotic multiple purpose shrubs/trees.

(P. S. Pathak)

Out of 32 species planted during 1985 four showed 100% mortality (*Acacia aneura*, *A. deamii*, *Mimosa tanuiflora* and *Parkinsonia aculeata*). Of the remaining *Acacia pennatula* showed peak height (3.72 m) and C. D. (4.68 cm) out of the other three species. The lowest remained in *A. mangium*. In *Albizia* species, *A. lebbek* recorded peak growth (2.21 m height and 2.4 cm C. D.) followed by *A. amara*. The Lucknow selection of *Prosopis juliflora* showed peak growth out of 3 collections (2.58 m height and 1.96 cm C. D.). Of the *Leucaena* accessions *L. leucocephala* and Silvi-4 remained almost at par (7.66 and 7.62 m height and 6.56 and 6.6 cm C. D.) with peak growth. The *L. leucocephala* × *L. diversifolia* hybrid performed better out of all other hybrids.

In these 1986 plantation, due to drought the mortality increased in many species.
### Table 11: Growth characteristics of *Leucaena* and *Eucalyptus* in shelter belts (6 month after planting)

<table>
<thead>
<tr>
<th>Attributes</th>
<th><em>Leucaena leucocephala</em></th>
<th></th>
<th><em>Eucalyptus hybrid</em></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Monocrop</td>
<td>ALA</td>
<td>APA</td>
<td>Monocrop</td>
</tr>
<tr>
<td>Survival (%)</td>
<td>97.7</td>
<td>98.0</td>
<td>97.3</td>
<td>87.4</td>
</tr>
<tr>
<td>CD (cm)</td>
<td>0.79</td>
<td>0.81</td>
<td>0.84</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>± .41</td>
<td>± .38</td>
<td>± .42</td>
<td>± .45</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>57.7</td>
<td>61.4</td>
<td>61.7</td>
<td>87.9</td>
</tr>
<tr>
<td></td>
<td>± 30.4</td>
<td>± 30.5</td>
<td>± 39.5</td>
<td>± 30.6</td>
</tr>
</tbody>
</table>

ALA = Alternate line arrangement, APA = Alternate plant arrangement

### Table 12: Survival and growth of 4 species of *Albizia* and *D. cinerea* in field.

<table>
<thead>
<tr>
<th>Species</th>
<th>Average survival (%)</th>
<th>Average growth in December</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>September</td>
<td>December</td>
<td>Height (cm)</td>
</tr>
<tr>
<td><em>A. amara</em></td>
<td>82</td>
<td>80</td>
<td>93.6</td>
</tr>
<tr>
<td><em>A. falcataria</em></td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>A. lebbek</em></td>
<td>88</td>
<td>81</td>
<td>43.2</td>
</tr>
<tr>
<td><em>A. procera</em></td>
<td>55</td>
<td>35</td>
<td>42.3</td>
</tr>
<tr>
<td><em>D. cinerea</em></td>
<td>97</td>
<td>97</td>
<td>65.2</td>
</tr>
<tr>
<td>Overall mean</td>
<td>68.0</td>
<td>73.2</td>
<td>61.1</td>
</tr>
<tr>
<td>SE (m) ±</td>
<td>32.0</td>
<td>26.7</td>
<td>24.1</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>62.8</td>
<td>52.2</td>
<td>47.3</td>
</tr>
</tbody>
</table>
Peak survival at the end of this year was in Sena atomaria (40%) followed by Dichrostachys cinerea (32.2%). Acacia tortilis and Albizia amara recorded 17.8% survival. The species showing 100% mortality were Anogeissus pendula, Enterolobium cyclocarpus, Albizia gucheppele Albizia carribea, Leucaena shanoni, Mimosa tenuiflora, L. diversifolia and Acacia deamii.

**ASP-2: EVOLVING SILVIPASTORAL SYSTEM FOR VARIOUS MARGINAL AND SUBMARGINAL WASTELANDS AND ENVIRONMENT**

**2.1 Studies on the Establishment, Growth and production of Acacia tortilis, Albizia amara and Hardwickia binata under various Silvipastoral combinations**

(R. Deb Roy, S. K. Gupta and T. A. Khan)

Alternate plants of Albizia amara and Hardwickia binata grown in the silvipastoral system with 4m x 4m spacing were removed during June/July in order to reduce the number of trees and to open the canopies for better pasture production. Growth and aerial biomass production of the trees were recorded. In order to introduce three-tier system seedlings of Leucaena leucocephala and Dichrostachys cinerea were planted in lines between trees at the ratio of 2:1 and their survival and growth were recorded. Inspite of poor monsoon Dichrostachys cinerea recorded 80 per cent survival compared to 62 per cent in Leucaena leucocephala.

**Growth and Biomass Production of A. amara and H. binata**

Growth in height, collar diameter (CD) and diameter at breast height (DBH) of both H. binata and A. amara under various silvipastoral combinations are presented in Table 13.

There was not much variation in the growth parameter within the treatment in H. binata although the growth was slightly better when grown without association. In A. amara maximum growth in height as well as DBH was observed with no grass association and the least in association with C. ciliaris pasture.

These trees were grown under the silvipastoral system since 1973 and as such at the end of 13 years H. binata recorded aerial biomass production of 32.5 t/ha or 2.32 t/ha/yr, in case of A. amara.

**Studies on coppice growth**: Coppice shoots were observed in more than 80 per cent in A. amara compared to 75 per cent in H. binata.

Coppice shoots in A. amara recorded maximum growth in height and CD of 209.6 cm and 1.60 cm compared to 158.5 cm and 1.8 cm respectively in H. binata. The former produced much higher coppice shoots (30.0) per stool than the latter (7.2). Maximum coppice shoots recorded per stool in A. amara were 75 compared to 29 in H. binata.
Coppice shoots recorded maximum dry biomass of 1.82 kg in *A. antara* compared to only 0.50 kg per stool in *H. binata* with in a period of 4 months.

**Pasture establishment and production:** After thinning the trees, attempt was made to renovate the pasture by introducing *Cenchrus ciliaris* and mixture of *Chrysopogon fulvus* and *S. nervosum* along with *Stylosanthus hamata*. But due to very poor monsoon and also very late commencement of rains the establishment of pasture was poor and patchy. Forage production of *C. ciliaris* varied from 5.3 to 25.7 q/ha to 4.5 to 29.3 q/ha in *Chrysopogon, Sehima* pasture. Pasture would be reestablished in the respective plots next year.

### 2.2 Increasing Production Potential of Wasteland through Silvipastoral System.

(R. Deb Roy, S. K. Gupta and M. M. Roy)

This is a long term study on the establishment/re-establishment, growth and productivity of various silvipastoral systems details of which are given below:

**Dichrostachys-Cenchrus/Chrysopogon silvipastoral system:** *Cenchrus ciliaris* and *Chrysopogon fulvus* were established during 1976-77 and *D. cinerea* was introduced in the pasture during 1981. Although pasture production has gone down especially of *Cenchrus* perhaps due to expansion of the side branches of *Dichrostachys* with about 600 plants per hectare and during year *Chrysopogon* recorded dried forage production of 3.53 t/ha compared to 2.02 t/ha in *Cenchrus* pasture, *D. cinerea* recorded mean growth in height, CD and DBH 467, 8.3 and 9.8 cm respectively. Growth in general during the year was poor may be due to late onset of the monsoon. Side branches would be pruned to allow more light to the pasture floor.

**Leucaena-Cenchrus/Chrysopogon silvipastoral system:** *Chrysopogon* recorded comparatively higher forage production of 3.43 t/ha compared to 2.86 t/ha in *Cenchrus*. In the long run *Chrysopogon* has been observed to have better persistency than *Cenchrus* pasture. Large number of seedlings of *L. leucocephala* have been established from the self sown seeds which also contributed towards pasture production especially its quality. *Leucaena leucocephala* recorded mean growth height of 10.2 m and CD & DBH of 16.80 and 14.61 cm respectively. The tree recorded maximum CD and DBH of 26.1 and 17.4 cm respectively.

**Albizia lebbek-Cenchrus-Sehima silvipastoral system:** *Sehima nervosum* recorded much higher forage production of 3.27 t/ha compared to 2.40 t/ha in *C. ciliaris* under the canopy of 10 year old *Albiza lebbek*. Inspite of poor and late monsoon during the year *Sehima* showed higher production compared to *Cenchrus*. Forage production was higher in *Cenchrus*.
Table 13. Growth and biomass of 14 year old *H. binata* and *A. amara* under silvipastoral system harvested in June/July 1987

<table>
<thead>
<tr>
<th>Silvipastoral treatment</th>
<th>Height (m)</th>
<th>C. D. (cm)</th>
<th>DBH (cm)</th>
<th>Bole + Branch (kg/tree)</th>
<th>Leaf (kg/tree)</th>
<th>Total biomass (kg/tree)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>H. binata</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T₁ S₁ G₀</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) With no grass</td>
<td>8.27</td>
<td>18.07</td>
<td>14.05</td>
<td>64.02 ±1.19</td>
<td>3.25 ±1.92</td>
<td>67.27 ±23.51</td>
</tr>
<tr>
<td></td>
<td>±0.73</td>
<td>±2.84</td>
<td>±2.29</td>
<td>±1.19 ±1.92</td>
<td>±1.92 ±23.51</td>
<td>±1.19 ±23.51</td>
</tr>
<tr>
<td>T₁ S₁ G₁</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii) with <em>C. ciliaris</em></td>
<td>7.82</td>
<td>17.98</td>
<td>13.83</td>
<td>59.24 ±7.24</td>
<td>2.81 ±1.01</td>
<td>62.05 ±14.81</td>
</tr>
<tr>
<td></td>
<td>±0.62</td>
<td>±2.19</td>
<td>±1.53</td>
<td>±7.24 ±1.01</td>
<td>±1.01 ±14.81</td>
<td>±7.24 ±14.81</td>
</tr>
<tr>
<td>T₁ S₁ G₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii) with <em>C. fulvus + S. nervosum</em></td>
<td>8.19</td>
<td>17.34</td>
<td>13.83</td>
<td>62.44 ±16.74</td>
<td>3.62 ±1.62</td>
<td>66.06 ±33.04</td>
</tr>
<tr>
<td></td>
<td>±0.96</td>
<td>±3.83</td>
<td>±3.17</td>
<td>±16.74 ±1.62</td>
<td>±1.62 ±33.04</td>
<td>±16.74 ±33.04</td>
</tr>
<tr>
<td>Mean</td>
<td>8.09</td>
<td>17.79</td>
<td>13.90</td>
<td>61.90 ±10.91</td>
<td>3.22 ±1.58</td>
<td>65.12 ±23.69</td>
</tr>
<tr>
<td></td>
<td>±0.80</td>
<td>±2.97</td>
<td>±2.30</td>
<td>±10.91 ±1.58</td>
<td>±1.58 ±23.69</td>
<td>±10.91 ±1.58</td>
</tr>
<tr>
<td><em>A. amara</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T₂ S₁ G₀</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) with no grass</td>
<td>8.36</td>
<td>15.58</td>
<td>26.68</td>
<td>73.29 ±42.71</td>
<td>5.90 ±3.38</td>
<td>79.17 ±46.09</td>
</tr>
<tr>
<td></td>
<td>±1.07</td>
<td>±4.30</td>
<td>±10.91</td>
<td>±42.71 ±3.38</td>
<td>±3.38 ±46.09</td>
<td>±42.71 ±3.38</td>
</tr>
<tr>
<td>T₂ S₁ G₁</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii) with <em>C. ciliaris</em></td>
<td>6.56</td>
<td>14.61</td>
<td>17.55</td>
<td>34.20 ±19.74</td>
<td>2.66 ±1.54</td>
<td>36.86 ±22.32</td>
</tr>
<tr>
<td></td>
<td>±0.76</td>
<td>±5.48</td>
<td>±6.16</td>
<td>±19.74 ±1.54</td>
<td>±1.54 ±22.32</td>
<td>±19.74 ±1.54</td>
</tr>
<tr>
<td>T₁ S₁ G₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii) with <em>C. fulvus + S. nervosum</em></td>
<td>7.29</td>
<td>19.06</td>
<td>22.60</td>
<td>48.10 ±21.72</td>
<td>3.74 ±1.69</td>
<td>51.84 ±23.41</td>
</tr>
<tr>
<td></td>
<td>±0.75</td>
<td>±3.87</td>
<td>±7.85</td>
<td>±21.72 ±1.69</td>
<td>±1.69 ±23.41</td>
<td>±21.72 ±1.69</td>
</tr>
<tr>
<td>Mean</td>
<td>7.40</td>
<td>16.43</td>
<td>22.28</td>
<td>51.86 ±18.52</td>
<td>4.10 ±1.47</td>
<td>55.96 ±19.99</td>
</tr>
<tr>
<td></td>
<td>±0.86</td>
<td>±3.27</td>
<td>±4.23</td>
<td>±18.52 ±1.47</td>
<td>±1.47 ±19.99</td>
<td>±18.52 ±1.47</td>
</tr>
</tbody>
</table>

*T₁ = H. binata, T₂ = A. amara, G₁ = C. ciliaris, G₂ = a mixture of C. fulvus + S. nervosum, S₁ = 4 x 4 m spacing.*
last year as compared to *Sehima* pasture. *Albizia lebbek* recorded a mean growth in CD and DBH of 24.2 and 21.5 cm respectively. Highest CD and DBH recorded were 37.8 and 34.3 cm respectively.

*Albizia procera-Cenchrus silvipastoral system*: In this system a few more trees died perhaps due to prolonged drought in addition due to root damage by termite. *Cenchrus* pasture was re-established during 1985 which recorded much higher forage production of 5.43 t/ha compared to other silvipastoral system. It may be mentioned that tree intensity is low—about 200–240 trees/ha. *A. procera* recorded a mean growth in CD and DBH of 31.1 and 30.0 cm respectively. The CD and DBH recorded were 44.0 and 39.8 cm respectively. In this species tree to tree variation in growth was much higher compared to *A. lebbek*.

*Acacia/Prosopis—Cenchrus—Chrysopogon silvastoral system*:

Both *Chrysopogon* as well as *Cenchrus* recorded higher forage production in association with *A. tortilis* than with *P. juliflora* (erect type) but it is not correct to assume that no grass grows under the canopy of *P. juliflora* provided one selects erect type (Israeli var.). *C. fulvus* recorded maximum forage production of 3.99 t/ha under *A. tortilis* and 2.94 under *P. juliflora* *A. tortilis* recorded higher CD (17.9 cm) compared to *P. juliflora* (16.4 cm) but the later recorded higher DBH (20.9 cm) due to more branching than the former (18.8 cm).

*Albizia-Leucaena silvipastoral system*:

Under the close canopy of *A. lebbek* with about 300 trees/ha *L. leucocephala* gave better forage production compared to *C. ciliaris*. Despite poor monsoon *Leucaena* produced dry forage production of 5.2 t/ha compared to only 2.2 t/ha. Shade tolerance of *Leucaena* can be taken advantage of producing its nutritious green fodder under the light canopies of trees like *A. lebbek*. *A. lebbek* recorded a mean growth in CD and DBH of 22.1 and 18.1 respectively. The maximum CD and DBH were 45.2 and 32.8 cm respectively.

Natural system control:

The natural protected rangeland comprised mostly of annual grasses like *Aristida*, *Eragrostis* with sporadic perennials like *Heteropogon contortus*, *Eremopogon* and occasional *Sehima nervosum*. The mean dry forage production recorded was 1.8 t/ha.

2.3 Silvipastoral Studies on *Dichrostachys cinerea* and *Albizia* spp.

(M. M. Roy)

*Dichrostachys cinerea*:
Average height and CD of established plants of *D. cinerea* (6 1/2 year) in association with pasture on highly calcareous wastelands were 362 cm and 7.6 cm respectively. Forage production recorded during November/December from various pasture combinations varied from 1.1 to 2.96 t (dry) ha\(^{-1}\) year\(^{-1}\). Peak forage yield was recorded from *Cenchrus ciliaris* + *Stylosanthes hamata* pasture, which was 15% less as compared to that obtained in 1986. From this year an additional dry fodder yield of 1.6 kg leaf, 1.1 kg pod and 4.3 kg firewood per plant (spacing 2 × 2 m) could be obtained by 50% lopping the plants during November. In the separate spacing trial on establishment and growth of *D. cinerea* in natural grassland no significant difference in establishment and growth was observed during 2nd year in different treatments. Average grass productivity recorded during Oct./Nov. varied from 2.23 to 3.25 t (dry) ha\(^{-1}\) yr\(^{-1}\). Average CAI in height and diameter was found to be 26 6 cm and 0.79 cm respectively.

*Albizia* spp. (*A. amara*, *A. lebbek*, *A. procera*).

Like previous years, yearly loppings in *A. amara*, *A. lebbek* and *A. procera* gave consistent fodder and firewood production. Fodder to firewood ratio increased in all the species. Highest increase was registered in *A. lebbek* (42.0%) followed by *A. procera* (10.7%) and *A. amara* (1.6%). Similarly pinnae to rachis ratio increased in all the species. Highest increase was registered in *A. procera* (13.1%) followed by *A. lebbek* (8.2%) and *A. amara* (4.3%).

Average crude protein in lopped fodder was 19.1%, 28.0% and 19.7% in *A. amara*, *A. lebbek* and *A. procera* respectively. ADF values for *A. lebbek* lopped fodder ranged from 32–37%.

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

(S. K. Gupta)

**Evaluation of *Acacia nilotica* and *A. tortilis* on calcareous wastelands at 4 1/2 years:**

Survival of *Acacia nilotica* and *A. tortilis* was higher than *A. nilotica*. In the former alternate line management system was better whereas in the later alternate plant management system was better in terms of survival. Growth in height was remarkably higher in alternate plant management system in *Acacia nilotica*. In case of *A. tortilis* also growth was more pronounced in alternate plant management system. Similar trend was found in growth in *C. D. in both the species* (Table-14). Yield of natural grasses on such land in ALM and APM system was 3.37 t/ha and 2.15 t/ha respectively. Similarly yield of sown stylo was 0.31 t/ha and 0.23 t/ha respectively.
Evaluation of A. nilotica, A. nilotica var. Cupriformis and A. tortilis in 15 different densities

In the first year there was no significant difference in survival and growth of the species in different treatments. Average growth and survival data of these species is presented (Table-15). Yield of natural grasses with these species was 5.27 t/ha, 5.68 t/ha and 5.07 t/ha, respectively.

Table 14: Performance of Acacia nilotica and A. tortilis on calcareous wasteland at 4-1/2 years of study

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Acacia nilotica</th>
<th>Acacia tortilis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ALM</td>
<td>APM</td>
</tr>
<tr>
<td>Survival (%)</td>
<td>61.11</td>
<td>82.35</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>213.89</td>
<td>361.00</td>
</tr>
<tr>
<td>CD</td>
<td>2.97</td>
<td>5.11</td>
</tr>
<tr>
<td>DBH</td>
<td>2.25</td>
<td>3.77</td>
</tr>
</tbody>
</table>

ALM = Alternate line management, APM = Alternate plant management.

Table 15: Survival and growth of three Acacia species

<table>
<thead>
<tr>
<th>Species</th>
<th>Survival (%)</th>
<th>Height (cm)</th>
<th>Basal diameter (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia tortilis</td>
<td>88.64</td>
<td>52.74</td>
<td>0.44</td>
</tr>
<tr>
<td>A. nilotica</td>
<td>86.98</td>
<td>74.54</td>
<td>0.73</td>
</tr>
<tr>
<td>A. nilotica var. Cupriformis</td>
<td>45.04</td>
<td>51.39</td>
<td>0.37</td>
</tr>
</tbody>
</table>
3.2 Establishment and growth of poplar clones in the agroforestry systems

(P. S. Pathak)

At the end of 2 year's growth poplars showed very high mortality due to intense summer of 1987. The clones giving 100% survival at 1 year recorded 13.9, 33.3, 8.3 and 36% survival (G 48, S7C1, S7C8 and G9 respectively). At 2 years the clones giving more than 50% survival were S7C20, S7C15 and S7C4 and were at par. S7C8 recorded the minimum survival (8.3%). The summer temperature and dryness do not appear to support growth.

Guinea grass recorded a peak production in EN-SW direction followed by E-W direction and the minimum remained in SE-NW direction. The high production was found to be associated with low receipt of photosynthetically active radiation. The leaf temperature remained low in plots producing high biomass which could be one associated reason for high production. Parameters like relative humidity, ambient temperature and soil temperature did not show any trend.

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

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

(P. S. Pathak and S. K. Sharma)

Seasonal growth pattern of lemon when grown with grasses: In the first season, the tree growth was maximum in control over intercrops. Plant height was maximum in control (64.67 cm) followed by the tree grown with Stylosanthes (57.00 cm) and Cenchrus (52.20 cm). Stem girth was maximum in control (0.95 cm) followed by Stylosanthes (0.80 cm) and Cenchrus (0.55 cm). The tree canopy was largest in control (NS 55 cm; EW 59 cm) and Cenchrus (NS 50.00 cm; EW 52 cm).

Seasonal growth pattern of Guava when grown with grasses: In the first season, the tree growth was better in plants grown without intercrops (control) than the plants grown with intercrops. Plant height was maximum in control (72.00 cm) followed by
Stylosanthes (65.03 cm) and Cenchrus (45.13 cm). Stem girth was also higher in the control (Stock, 0.72 cm, Union, 0.25 cm; Scion, 0.68 cm) followed by Stylosanthes (Stock, 0.67 cm; Union, 0.81 cm; Scion, 0.63 cm) and Cenchrus (Stock, 0.52 cm, Union, 0.67; Scion, 0.50 cm). The tree canopy was largest in control (N-S, 65.00 cm; E-W, 60.00 cm) followed by Stylosanthes (N-S 58.00 cm; E-W 52.00 cm) and Cenchrus (N-S 43 cm; E-W 51 cm).

ASP-5. EVOLUTION OF NEW GENOTYPES/IDEOGENES OF VARIOUS TOP FEED-CUM-ENERGY PRODUCING SPECIES

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

(V. K. Gupta)

Evaluation of Leucaena species and hybrids received during 1982-83: 4.5 year old tree of seven Leucaena species viz., L. diversifolia(K156 and 78-49), L. lanceolat (K10), L. shannoni (78-40), L. trichodes (78-86), L. macrophylla (K 78), L. macrophylla (K 381) and two hybrids of L. leucocephala; L. pulverulenta with K8, K28 and IGFRI 23-1 (plus selection of L. leucocephala) were harvested. Data were recorded on plant height, CD, DBH, forage yield, fuelwood and branch yield. IGFRI 23-1 and one interspecific hybrid were 37.64% and 88.93% for bole weight; 10.5% and 183.6% for branch weight and 28.86% and 118.70% for forage yield superior than standard variety K8, respectively. These also had high magnitude for CD, DBH and plant height.

Evaluation of new lines of L. leucocephala received in year 1988 with K8, 28 and IGFRI 23-1: Twenty seven new lines of L. leucocephala received during 1983-84 were harvested this year and data were recorded on plant height, CD, DBH, stem weight, branch weight, forage yield and reaction against gummosis disease. None of the accessions was better than IGFRI 23-1. However, for fuelwood yield. IGFRI 101 (19.8kg DM/plant) was better than K8 (12.32 kg DM/plant). For forage yield all the high yielding accessions were at par with K1. IGFRI 85, IGFRI 103 were at par with K8 for fuelwood yield. Gummosis was observed in accessions IGFRI 80 and IGFRI 82, Accession IGFRI 1102 flowered very late.

Evaluation of new introductions of L. shannoni, L. diversifolia, L. species (unidentifed) and L. leucocephala received in year 1985-86 with K8, K28 and IGFRI 23-1: Twenty three strains of L. shannoni, 25 of L. diversifolia and 26 L. species (unidentified) and 13 of L. leucocephala were evaluated for growth parameters i.e. plant height, CD, DBH and days to first flowering. All the accessions of L. shannoni, L. diversifolia, L. species (unidentified) were inferior to L. leucocaphala in growth parameters, However, these accessions did not flower even in
two years which is a negative character in *L. leucocephala*. Out of 13 strains of *L. leucocephala* belonging to K600 and K700 series, 10 strains were superior over K8 for plant height and collar diameter. They flowered comparatively late with less seed yield.

**Evaluation of Leucaena species received during 1984–85**

Four strains of *L. diversifolia*, two strains of *L. pulverulenta*, one strain each of *L. macrophylla*, *L. collinsii*, *L. esculenta*, *L. insularum*, *L. shannonii* and four strains of *L. leucocephala* were evaluated for growth parameters and days to flower. *L. collinsii* and *L. mycrophylla* are yet to flower. Performance of *L. pulverulenta* (90-91, K19) *L. collinsii* was good. All the four strains of *L. leucocephala* were inferior to K8 in these parameters.

**Interspecific hybrids (F₁ population)**

Hybrid vigour study was done in interspecific hybrids of *L. lanceolata* × *L. leucocephala*, *L. macrophylla* × *L. leucocephala*, *L. mycrophylla* × *L. lanceolata*, *L. shannonii* × *L. leucocephala* and *L. leucocephala* × *L. pulverulenta* for CD, DBH and plant height. For all the growth parameters, positive and significant hybrid vigour was observed only in *L. leucocephala* × *L. diversifolia* and *L. leucocephala* × *L. pulverulenta* crosses. Hybrid vigour was 64.88 and 94.33 percent for CD in the former and latter respectively. Similar for plant height magnitude was 42.68 and 23.80 percent in the former and latter respectively.

**Interspecific hybrid (F₂ population)**

F₂ populations of seventeen crosses with their eight parents and F₁ were evaluated for growth parameters. Thirty seven trees having height more than 850 cm and CD 8.5 cm were superior over K8 (750 cm, 7.3 cm) and IGFRI 23–1 (80.0 cm). These trees belong to crosses IGFRI 33 × IGFRI 31, IGFRI 1–29 × IGFRI 31, IGFRI 18 × IGFRI 8 and IGFRI 31 × IGFRI 41.

Regeneration capacity in the second and third cycle was recorded in F₂ populations of fifteen crosses. Progenies of IGFRI 7 × IGFRI 14, IGFRI 14 × IGFRI 18 and IGFRI 14 × IGFRI 23 were promising and better than K8. Maximum aboveground biomass was obtained in the second cycle in progeny of IGFRI 15 × IGFRI 18 (76.5 t/ha/yr.) against 54.64 t/ha/yr. in K8.

**Interspecific hybrids (F₃ populations)**

Twenty eight single plant progenies of selected F₂ plants were raised this year and data were recorded on growth parameters. This year there were no significant differences in growth parameters.
ASP—6 : MODELLING FOR GROWTH AND PRODUCTIVITY IN MULTIPURPOSE WOODY PERENNIALS

6. 1. *Leucaena leucocephala*

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

Based on previous years findings, data on trees of sample sizes 25, 15, 21, 19 and 20 with growth of 3.5, 4.5, 5.5, 6.5 and 7.5 years were tried to decide the transformation function for its normality for statistical interpretation. \( Y = \log (1 + x) \) was found appropriate for normality of data pertaining to growth and production traits in these tree species. Variation in data shows reduction after 6.5 year growth. Simple regression of component of aboveground biomass with basic growth attributes recorded less variation with respect to DBH. Following prediction equation are found good with good precision:

Total above ground biomass (kg) \( Y = -1 + 0.0646 (1 + DBH) \)
\[ R^2 = 98.29\% \]
\[ sd = 0.1542 \]

Bole (stem) weight (kg) \( Y = -1 + 0.0584 (1 + DBH) \)
\[ R^2 = 97.42\% \]
\[ sd = 0.1351 \]

Branch weight (kg) \( Y = -1 + 0.0773 (1 + DBH) \)
\[ R^2 = 87.50\% \]
\[ sd = 0.3058 \]

Leaf weight (kg) \( Y = -1 + 0.1631 (1 + DBH) \)
\[ R^2 = 85.51\% \]
\[ sd = 0.226 \]

\( DBH = \) Diameter at breast height.

Less variation in the standard error of biomass component with DBH shows optimum fitness. Analysis for a statistical test for stability of regression over the period of time is in progress.

6. 2. Other trees

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

Data on 44 trees of 13 years growth of 49 of *Acacia tortilis*, 49 of *Hardwickia binata* and 20 trees of *Albizia amara* (both of 14 years) were selected and transformation function were decided to make the data normal for detailed statistical analysis. For *Acacia tortilis* and *Hardwickia binata*, function \( Y = \log (1 + x) \) was appropriate for normality of data. Further, detailed statistical analysis is in progress.
DIVISION OF SOIL SCIENCE

SS-1: SOIL STUDIES UNDER INTENSIVE FORAGE PRODUCTION

1.1 Evaluation of multipurpose trees/shrubs as organic manures for forage production

(I. Y. L. N. Murthy, C. R. Hazra and Ashok Kumar)

A field trial was conducted with Sorghum cv. M. P. Chari as a test crop, to evaluate the residual fertility of the previous kharif season conducted experiment with same crop, under three nitrogen levels (60, 90 and 120 kg N/ha) as derived from different sources viz Urea, Urea + *Leucaena* leaf meal (1:1) and Urea + Neem leaf meal (1:1). The herbage yield of Sorghum progressively increased with the higher doses of nitrogen. The beneficial effect of organic + inorganic fertilization was reflected in the 10 to 11% higher yield obtained from Urea + Neem and Urea + *L. leucocephala* leaf meal both in 1:1. Looking at the residual soil fertility the higher organic carbon content was observed with the organic + inorganic fertilization with both the leaf sources. This further resulted in higher availability of N, P and K to the extent of 6-10 kg N/ha, 4.1-4.3 kg P/ha and 45.4-45.7 kg/ha.

In another experiment laid out with treatments similar to previous year as indicated above, Sorghum cv. PC-6 was the test crop. The crop yields increased up to 120 kg N/ha. The organic and inorganic fertilizers through urea and leaf residues of subabul and neem showed the possibility of 50% of fertilizer nitrogen substitution through the tree leaves. The higher yield was associated with Urea + Neem leaf application each at the level of 60 kg N/ha. The increased nitrogen fertilization improved the soil fertility status in terms of availability of major nutrients (NPK) and organic carbon content. Further the leaf meal incorporation improved the organic carbon status of the soils as compared to the single application of nitrogen through urea. Availability of major nutrients also showed the similar trend.

1.2 Studies on bacterial mediated N\textsubscript{2}-fixation for increased productivity in cultivated fodder crops

(M. R. Palwa)
Nitrogen fixing capacity of the isolates of *Azotobacter chroococcum*

Twenty isolates recovered from the rhizosphere of fodder oat and sorghum were tested for nitrogen fixing capacity. Five strains (Og, O5, O6, O8 and O9) pertaining to oat and three of sorghum (S3, S5 and S9) were found to be high in the range of 15-21 mg N fixed per g glucose consumed. Production of indole compounds by three strains (S3, S5 and S9) of *Azotobacter chroococcum* varied from 3-6 ug IAA equivalents/ul culture fertilate.

**Efficient host-Azospirillum interactions**

Pot studies were conducted on oat, maize, pearl millet and sorghum cultivars in order to select a superior combination of host and *Azospirillum* for improved productivity and quality. The results are given below:

(i) Of the eight oat cultivars (Kent, OS-6, OL-88, OL-99, JHO-817, JHO-822, UPO-222 and UPO-223) evaluated for their compatibility with respect to *Azospirillum brasiliense* ICM 1002, only three (Kent, OS-6 and JHO-822) interacted significantly in increasing plant height, number of tillers, dried root biomass, forage yield and crude protein content in crop with inoculation. Oat variety JHO-222 and *Azospirillum* association was most compatible as it exhibited highest forage yield (48.8 g/plant, DM-11.7 g/plant) rich in crude protein (10.8%). Plant height (107.8 cm) and number of tillers/plant (7) also followed the same trend. Dry root biomass (3.4 g/plant) and its nitrogen content (1.4%) also increased significantly in this inoculated variety. Highest of *Azospirillum* (17 x 10^4 cells/g dry soil) in the rhizosphere of the inoculated JHO-822 variety further demonstrated the compatibility and the superiority of such association.

(ii) Between the two species of *Azospirillum* when inoculated separately in maize (African Tall), sorghum (M. P. Chari) and bajra (Rajkoo), the homologous strain *A. lipoferum* ICM 1001) for maize and sorghum produced significant positive effects on yield and crude protein content (maize green matter yield-49.8 g/plant DM10.4 g/plant, ht(cm)-19.3/plant, dried root weight 3.5 g/plant, C. P. content-8%, sorghum-34.2 g, 10.6, 115 cm, 2.9 g & 6%, respectively), while this was not true in case of bajra where *A. brasiliense-2* indicated superior performance (Green fodder yield-46.6 g/plant, DM-11.3 g/plant, ht(cm)-131.5,dried root biomass 3g/plant, C.P. content-5.7%). Crop response to microbial inoculation.

(a) Eight treatment comprising four levels of nitrogen (0,30,45 and 90 kg N/ha) with and without *A. lipoferum* ICM 1001 inoculation were tried on sudan sorghum in R. B. D. with three replications. Significant improvement in green forage yield in two cut
was obtained due to nitrogen as well as with *Azospirillum* inoculation. Simple inoculation registered 29% higher green matter yield (C—250 q/ha, I—315 q/ha). Inoculation effects were significant at low levels (0 to 45 kg N/ha). Inoculation revealed a saving of about 15 kg N/ha ascomparable green and dry matter accumulation was no iced at 30 kg N/ha with inoculation and 45 kg N/ha alone (30 kg N/ha + I = 355.5 q/ha, DM = 85.2 q/ha.) The efficacy of the inoculum was high at 30 kg N/ha (11% more green matter yield) which recorded the highest number of *Azospirillum* cells in the rhizosphere (28 x 10^3 cells/g dry soil).

(b) In mustard, seed inoculation with *Azotobacter chroococcum* 2001 significantly increased plant height (64.6 cm), green forage yield (+36.0%) and dry matter content (+35.7%). The highest green forage yield (19 g/plant, DM 3.2 g/plant) rich in crude protein (10.9%) was obtained with 60 kg N/ha + inoculation treatment. Nitrogen uptake (60 kg N/ha — 46 mg/plant, 60 kg N/ha + I — mg/plant) by the crop also increased markedly with this combined treatment.

(c) Investigation on the associative effect of microbial inoculants revealed significant effect on nodulation (48/plant), root length (19.5 cm/plant), green forage yield (9.6 g/plant) as well as on CP content (15.4%) in berseem due to combined application of *Rhizobium trifolii* BJ-9 and *Azospirillum brasilense*—2 (IARI).

(d) Beneficial effects of combined inoculation of *R. trifolii* and *Glomus fasciculatum* (VAM fungus) in presence of 40 kg P_2O_5/ha were at par with *Rhizobium* +80 kg P_2O_5/ha on berseem (RI+VAM+40 kg P_2O_5 — nodules — 38/plants, root length (cm)/plant — 22.4 cm, green forage yield — 9.1 g/plant, DM yield — 2 g/plant, CP content — 16.5% and RI + 80 kg P_2O_5/ha — 42, 21.6 cm, 9.2 g, 2 g/plant and 16.2%, respectively).

### 1.3: Improving forage productivity and efficacy of indigenous rock phosphates through phosphate solublizing microorganisms

(M. R. Pahwa)

**Efficiency of phosphate dissolving bacteria**

Four species of phosphate solublizing bacteria viz. native bacteria, *Bacillus cereus*, *Bacillus sp.* and *Bacillus polymyxa* H_3 and *Pseudomonas straita* from IARI, were evaluated for phosphate solubilization using red soil treated with Mussoorie rock phosphate. The inoculant cultures behaved differently in this type of soil. Native cultures affected higher release of P during the second week (17.5 ppm), while the exotic inoculants obtained from IARI, caused gradual increase in available P upto six weeks.
Crops response to phosphate solublizing microorganisms, rock phosphate and rock-pyrite amendments.

Eight treatment combinations comprising of two levels each of Mussoorie rock-phosphate (0 and 100 kg P₂O₅ /ha) and rock-pyrite (0 and 2t/ha with and without phosphate solubilizing bacterium) *Bacillus polymyxa* Hs were tried in pots filled with red soil pH- 8.20 on lucerne, seed were uniformly applied with the pure culture suspension of *Rhizobium melilotii* LJ – 13.

The data recorded on 70th day indicated significant effect on nodulation (20/plant), root length (14.4 cm/plant), green forage yield (+28.8%) as well as on crude protein content in plants (19%) with phosphate solubilizer.

The combined treatment involving rock-phosphate, rock-pyrite and phosphate solubilizing culture interacted significantly in enhancing nodulation (36/plant), root length (17.1 cm/plant), green (13.6 g/plant) and dry matter forage yields (2.3 g/plant). Similar positive effect was also reflected in P uptake by the crop.

1.4 Weather and microclimatological analysis in forage crops

(Pradeep Behari and C. R. Hazra)

Studies on intercropping system in relation to row proportion of oats and legumes

Oats was combined with three legumes viz. pea, senji and lucerne in row proportion of 1:1, 2:2, 3:3 and 4:4 in substituted series. Four treatments of pure oats, pea, senji and lucerne were also sown for the second successive year on silty clay loam soil. In general the legume incorporation with oats depressed the herbage productivity of oats as well as the total productivity. The lucerne with oats in 4:4 and senji with oats in 3:3 proportion gave LER values more than one (1.0 — 1.05). Amongs the three legumes as a sole crop, senji gave the highest yield of 137 q/ha of green forage, whereas the highest dry forage yield of 22.7 q/ha was recorded in pea. The total herbage productivity, on an average, in any of the intercropping with legume was not significantly influenced in terms of total green forage (197.8—202.8 q/ha) and dry forage (41.0 — 45.1 q/ha). The highest herbage yield was obtained in pure oats 250.7 q/ha green and 55.0 q/ha dry.

The cereal component had higher canopy-air temperature difference as compared to legume component in a given row proportion. Among the different legumes, lucerne had higher leaf temperature followed by pea and senji.
The soil temperature in general was higher in the intercroppings during January as compared to the pure oats. However, this was reversed during March. In the intercropping system pea received relatively higher radiation as compared to senji and lucerne.

1.5 Evapotranspiration studies in forage crops through lysimetry

(Pradeep Behari)

The daily evapotranspiration measurement of cowpea was made using replicated gravimetric type lysimeters during kharif 1987. The crop was sown uniformly in an around the lysimeter tanks at a spacing of 30 cm. During growth period of 53 days cumulative evapotranspiration worked out to be 282.8 mm with a mean value of 5.4 mm/day. The green and dry matter yields of cowpea were 230.77 q/ha and 48.47 q/ha of lysimeter and 110.35 q/ha and 22.76 q/ha in the remaining area. The computed water use efficiency was 16.96 kg DM/ha/mm.

SS-2. SOIL STUDIES OF RANGELANDS AND PASTURE

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

(M. R. Pahwa)

Efficiency of phosphate solubilizer in Centrosema-Rhizobium symbiotic system

The treatment combination involving two phosphate carriers viz. single superphosphate, Mussoorie rock phosphate each at three levels (0, 50 and 100 kg P₂O₅/ha), were tried in plots in presence and absense of phosphate solubilizer, Pseudomonas strata on rhizobia (strain TAL-651) inoculated Centrosema pubescens. Phospho-bacterized seeds alone exhibited improvement in nodulation (58/plant), root length (26.6 cm/plant) as well as helped in producing 25% more green forage yield over control. Both the sources of phosphates at 100 kg P₂O₅/ha along with phosphate solubilizer were observed to be at par in respect of forage yields (MRP+PI=20 g/plant, DM=6 g/plant, SSP+PI=20.5 and DM=6.2 g/plant) and uptake of P by crop.

Azospirillum for grass species

(a) Of the eleven strains of Azospirillum species A. lipoferum ICM 1001, A. brasilense -2, A. b. 7a, A. b. ICM-1002, A. l. -1, A. b. -2 (ICRISAT), A. l.-IG5, A. b.-1, A. b.-3, A. l.-2 and A. b. ICM1003) examined for their relative efficacy on Cenchrus ciliaris, only strain
ICM 1001 of *A. lipoforum* recorded significantly higher forage yield in two cuts (C-38.3 g/plant DM-11.6 g/plant, I-70.9 g/plant, DM-21.7 g/plant). Stimulatory effect on crude protein (8.2%) in plants was also observed at the first cutting stage with this strain of *A. lipoforum*.

(b) Out of the three homologous strain of *Azospirillum lipoferum* (*A. l.-1, A. l.-2, A. l.-ICM 1001*) evaluated for their effectiveness in terms of productivity and quality on three grass species (*Cenchrus ciliaris, C. setigerus* and *Dichanthium annulatum*), strain-1 gave superior performance in all the grass in two cuts (*Cenchrus ciliaris*—*C*—total green forage yield)—43.9 g/plant, I–63.9 g/plant *C. setigerus*—*C*–29.1 g/plant, *D. annulatum*—*C*–21.7 g/plant I–38.9 g/plant. Seedling inoculation with strain also increased the CP content in these during first cutting stage the highest being *C. setigerus* (8%).

(c) Field response of *Cenchrus ciliaris* to separate inoculation with seven strains of both *Azospirillum* species indicated higher green forage yields benefit (+35%) in two cuts on account of two homologous strains (*control total green forage yields—135 q/ha, A. l.-2 185.5 q/ha* while *A. brasilense* strains (*A. b.-1, A. b.-2, A. b.-2 (ICRISAT), A. b.-3 and A. b.-ICM 1002*) recorded only 14.8 to 26% increase in yield over uninoculated control.

### 2.2 Glimpses of Grazing in India

(R. K. Tyagi)

**Studies on grazing resources**

The analysis of the data indicated that out of the total reported area of the country i.e. 304.21 million hectares (1983–84) the forests cover 22.13 per cent of lands. Permanent pasture and miscellaneous tree crops and groves occupy only 3.94 and 1.14 per cent area respectively. The cultivable wasteland were 5.08 per cent while the fallow land covered 7.52 per cent area. Thus, the total area available for grazing accounts for 39.81 per cent in the country. In eight states more than 50 per cent area is utilized for grazing whereas in the states like Himachal Pradesh, Jammu and Kashmir, Meghalaya, Arunachal Pradesh it is more than 70 per cent. However, in some of states forest constitute the major proportion where very little grazing is practised.

### 2.3. Studies on soil fertility and nutritional status of grass covers of Bundelkhand region

(R. K. Tyagi, P. Kumar, B. K. Trivedi, K. S. Ramachandra and I. Y. L. N. Murthy)

Soil samples at two depths (0–15 cm and 15–30 cm) were collected from the grass
lands/grazing lands of two districts of Bundelkhand region, Lalitpur and Tikamgarh to study the physico-chemical properties. Surface soil of Lalitpur showed slightly alkaline with low organic carbon percentage and available nitrogen and phosphorus compared to Tikamgarh soils. Surface soils of Lalitpur and Tikamgarh recorded rich potassium 412.9 kg/ha and 519.2 kg/ha contents respectively. Texture of Tikamgarh soil was sandy clay loam whereas Lalitpur soils showed both sandy clay loam nature. Saturation percentage of Tikamgarh surface soil indicated 42.7 compared to 34.3 of Lalitpur soils. Both the district soils were poor in major nutrient status but rich in potassium content (Table-16).

The nutritional quality of herbage samples collected from Lalitpur and Tikamgarh districts revealed that the total ash content varied from 7.07 to 15.72 percent (Fig. 1). The data showed that C. P. content was 3.15 to 3.96 per cent. It can hardly maintained the animal in nitrogen equilibrium. For normal needs the C. P. level desired is 10–12 per cent The structural carbohydrates (NDF, ADF, lignin and cellulose) also did not very significantly from site to site as well as district to district except for lignin in one location.

The copper content varied from 4.99 to 11.24 ppm on dry matter basis. In all the location it is almost below the normal requirement (10 ppm). The zinc content of these samples is in between 8.98 to 15.74 ppm on DM basis. These values are of lower order and much below the zinc requirement of animals (45 ppm). There is considerable variation in the levels of iron content which varied from 26.22 to 124.91 ppm in DM basis. The iron requirement also can be met with from the grazing alone and therefore supplementation of these two elements (copper and zinc) is considered essential for grazing animals of this region (Fig. 2)

The above studies indicate that the lower availability of nitrogen from the soil reflected in its poor uptake by grasses. Thus these grasses had very low crude protein content (3.15–3.96%). The higher biomass production of grasses like *Iseilema laxum*, *Heteropogon contortus* and *Dichanthium annulatum* at Badagaon area, despite high sodium concentration and pH (8) at surface soil level was an indication of their suitability under such problematic conditions.

Table-6 : Physico-properties of Lalitpur and Tikamgarh Soils

<table>
<thead>
<tr>
<th>Depth</th>
<th>pH</th>
<th>OC%</th>
<th>Nitrogen kg/ha</th>
<th>Phosphorus kg/ha</th>
<th>Potash kg/ha</th>
<th>Saturation %</th>
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<td>Lalitpur</td>
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<td>0–15 cm</td>
<td>7.45</td>
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<td>156.0</td>
<td>4.65</td>
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<tr>
<td>15–30 cm</td>
<td>7.51</td>
<td>0.41</td>
<td>137.2</td>
<td>2.88</td>
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<td>36.7</td>
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<td>Tikamgarh</td>
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<tr>
<td>0–15 cm</td>
<td>7.05</td>
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<td>7.84</td>
<td>519.3</td>
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<tr>
<td>15–30 cm</td>
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<td>0.42</td>
<td>110.5</td>
<td>2.24</td>
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</table>
Fig. 1: Nutritional status of grass cover of Bundelkhand region.

Fig. 2: Soil fertility of grass covers of Bundelkhand region.
3.1 Studies on bacterial mediated \( N_2 \)-fixation under agroforestry system of forage production

(M. R. Pahwa)

**Performance of Leucaena species - with respect to Rhizobium strains:** Three species of *Leucaena* species (*Leucaena leucocephala, L. shannoni* and *L. lanceolata*) were tested against two strains of *R. loti* (L. L. - 28-2 and TAL - 582) for selecting the preferential genotypic association between *Leucaena* host species and Rhizobium strain.

The association formed between either of the two strains of Rhizobium and *Leucaena leucocephala* Var K-8 were found to be superior and also did not differ significantly in terms of nodulation, root length, and biomass production. This indicates the compatibility of *Leucaena leucocephala* host with respect to these strains for augmenting biomass yield.

**Associative effects of microbial inoculants on Leucaena leucocephala:** Three different microbial inoculants viz, VAM fungi (*Glomus fasciculatum*), *Rhizobium loti* TAL-582 and phosphate solubilizing bacterium (*Pseudomonas strain*) were tried singly and in combination on *Leucaena leucocephala* Var K-8 under potted conditions using red soil.

Associative effects of three microbial inoculants were found to be more pronounced in regard to nodulation (15/plant), root length (35.5 cm/plant), herbage yield (8 g/plant) as well as no crude protein content (28.1%) in *Leucaena leucocephala* var K-8. The uptake of N also appeared to be the highest under combined microbial inoculants (122 mg/plant).

3.2 Micro-meteorological studies in multicanopy cropping situation

(Pradeep Behari and P. S. Pathak)

A field experiment was conducted with Guinea grass as understory component under agroforestry system. The different agro-systems include 3 tier and 2 tier involving Populus, Subabool and Guinea grass in the former system and Subabool and Guinea in the later system and the third system involving Guinea open canopy situation. The micrometeorological study was undertaken on various parameters like photosynthetically active radiation, relative humidity, leaf temperature, soil temperature, and ambient air temperature. The measurement was taken throughout the entire growth period of Guinea grass in to different times in a day (10 30 Hrs and 3.30 Hrs) at fortnightly interval,
The level of incoming radiation to the Guinea grass surface varied with the cropping systems. The highest amount of average radiation coming to the open canopy surface (962 uE/m²/S) followed by 2 tier situation with 66% of open radiation and only 24% under 3 tier situation. The relative humidity was on the reverse order of the incoming radiation i.e. highest relative humidity with 3 tier followed by 2 tier and lowest with the open canopy situation. The leaf temperature, ambient air temperature and soil temperature were recorded lowest values under 3 tier system followed by 2 tier system and the highest values associated with the open canopy situation.

4.1 Evaluation of grasses under different sodicity and pH levels

(Dashrath Singh and Raj Bahadur)

A pot culture experiment was conducted in two different soils viz; red and medium black soils. Five treatments (0, 20, 40, 60, and 80 ESP) and three grasses Hybrid napier, Setaria and Guinea grasses were tried. The red soil pH varied from 7.4 to 10 (7.4, 8.6, 9.5, 9.7, and 10) while black soil pH ranged from 7.2 to 9.6 (7.2, 8.3, 9.0, 9.3 and 9.6). After two cuts it was observed that the Guinea grass survived both in red (8.6 pH) and black soils (8.3 pH) up to 20 ESP, whereas in the red soil Hybrid napier and Setaria tolerated even up to 60 ESP and 9.7 pH. However, in black soils at 9.6 pH and 80 ESP only Sataria survived. Thus Sataria is the most suitable grass for red and black problematic soils because of its tolerance to higher pH 9.7 as well as ESP 60–80. For higher biomass production of these grasses the optimum pH and ESP are 8.6 and 20 respectively.
DIVISION OF PLANT ANIMAL RELATIONSHIP

PAR-1: NUTRIENT LEVELS AND ANTIQUALITY FACTORS

1.1 Studies on chemical attributes of improved varieties of cultivated fodder and forage crops

(L. K. Karnani)

Samples of final evaluation trial on 12 varieties of oats were collected at 50% flowering stage and analysed for DM, NDF, ADF, cellulose, lignin, silica, total Ash, acid insoluble ash, hemicellulose and IVTDMD.

The dry matter was maximum (29.0%) in variety OL-126 and minimum (18.0%) in JHO-827. Variety Kent had NDF 52.09%, ADF 32.15%, hemicellulose 19.94%, cellulose 28.81%, lignin 2.10% and IVTDMD 68.11%. OL-129 had the highest NDF, ADF and cellulose (63.93, 39.96 and 33.99% respectively). However, PO-22 had maximum hemicellulose (28.01%) and OS-121 the maximum lignin content (4.72%).

IVTDMD showed no significant correlation with any of the chemical components studied. However, significant correlations were observed between NDF and characters like ADF (r=0.8558), hemicellulose (r=0.6681) and cellulose (r=0.6543) and also between ADF and cellulose (r=0.7895). Significant correlation also existed between silica and acid-insoluble ash (r=0.6080).

The IVTDMD values of all the varieties tested ranged between 62.52 to 69.71% and the crude protein varied between 4.24 (in OL-233) to 5.95% (in OS-129).

1.3 (a) Ensilage of herbages and crop residues

(A. P. Singh and A. Rekib)

Effect of dry grass ammoniation on its utilization

Chaffed natural dry grass was ammoniated with 2% (T₀) and 4% (T₂) urea in silo pits with about 40% water. These were opened for feeding to cross-bread calves after about 30 days of ammoniation. The ammoniated materials were chemically analysed for soluble
N, NH₃-N, total N, pH and acetic butyric and lactic acids. The analysis was repeated several times during the two conservation and feeding trials run for 5 months. The respective values in T₂ and T₃ were: N 0.556, 0.88; NH₃-N 0.371, 0.548; total N 1.062, 1.669%; pH 6.89, 7.17; acetic acid 2.19, 3.04%; butyric acid 0.55, 0.25% and lactic acid 0.23 and 0.158%. Coefficient of analytical variation was within 5 to 35% for all the constituents except for butyric and lactic acids where it was over 110%.

Two feeding trials were conducted consecutively. In the Trial-I concentrate consisted of Agro-concentrate-milch ration and in the Trial-II oat grain. The Trial-I continued for 90 days and the Trial-II for 60 days. The treatments in both the trials were as follows:

- **T₁** — Control — without ammoniation + 1% concentrate on b.w.
- **T₂** — 2% ammoniated grass + 0.5% concentrate on b.w.
- **T₃** — 4% ammoniated grass + 0.5% concentrate on b.w.

Average CP, NDF, ADF, HC, cellulose and lignin were 3.36, 6.87, 10.23, 79.46, 81.41, 78.44, in T₁; 47.75, 51.02, 54.04, 31.71, 30.39, 24.40 in T₂ and 37.80, 40.78, 42.53, 9.85, 10.24, 11.51% in T₃ respectively.

**Feeding Trial-I**

DM intake was significantly higher for 2% ammoniated material. Grass and grass+concentrate intake were: 1.83, 2.71 in T₁, 2.09, 2.54 in T₂ and 1.69, 2.14% in T₃, respectively. In T₁ body weight gain/day was 512 g as compared to 290 g in T₂ and 316 g in T₃. Blood urea levels were 22.7, 33.2 and 62.4 mg% in T₁, T₂ and T₃, respectively. Feed cost per animal/day (at 200 kg bw) and feed cost for 1 kg body weight gain were 6.70, 13.08: 4.67, 16.10 and 4.69, 14.84 in T₁, T₂ and T₃, respectively. These observations indicated that though the feed cost per animal was reduced considerably due to ammoniation, feed cost per unit body gain was more for the ammoniated material. The blood urea level was a little on the higher side in T₃ (4% ammoniated) which might cause some abnormality in the animals fed with it for a longer period. Though better weight gain was obtained in T₃ than T₂, the difference was not significant.

**Feeding Trial-II**

The DM intake through roughage as well as digestibility of various nutrient of grass as well as grass+oat varied within a narrow limits, except the digestibility of HC which was significantly higher in T₃ (4% urea treated grass) (79.1%) followed by T₂ (2% urea treatment) (75.0%) and control (47.9%). The CP digestibility considerably increased (though not significant due to high individual variation) due to ammoniation. The % DCP and
% TDN values of grass and grass+concentrate mixture were 0.75 and 43.4; 2.49 and 53.8; 1.79 and 46.0; 2.51 and 50.9; 3.78 and 46.6; 4.16 and 51.7 in T1, T2 and T3, respectively. Body weight gain were 291, 273 and 272 g per animal/day in T1, T2 and T3, respectively. The feed cost per animal (of 200 kg b.w.) per day and feed cost per kg body weight gain were 4.90, 16.79, 3.98, 14.58, 3.99 and 14.69 in T1, T2 and T3, respectively. The cost of ammoniated feed material was cheaper over control. Blood urea levels were 12.4, 19.6, and 30.7 mg% in T1, T2 and T3 respectively. The blood urea levels were under reasonable limits even with feeding of the 4% urea treated material. The 4% urea treated material was however not superior 2% urea treatment.

1.3 (b) Evaluation of different species/varieties of forage as silage

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

Ensilage of fodder sunflower

Fodder sunflower variety EC-68414 was harvested at full flowering stage and ensiled in pit silos after wilting it for 24 hours. The fresh forage contained 7.98% CP, 9.82%WSC 0.41% WSN and 1.27% total nitrogen with pH 6.3.

The silo opened after 90 days of ensiling were of green colour and possessed a pleasant aroma. The chemical and bio-chemical composition of silage is as follows—pH 5.56, NH3-N 0.125%, TN 1.1552%, acetic acid 6.45%, Hemicellulose 26.31%, NH3-N% TN 10.82, FI 50, CP 7.19%, NDF 68.75%, ADF 42.45%, and cell content 31.24%. The silage was less stable (L % T-14.37, Fleig index 50) and when fed to six crossbred calves ad lib for 60 days the dry matter intake was 1.92 ± 0.18 kg per 100 kg body weight.

Ensilage of berseem plus dry grass

Berseem and dry grasses were chaffed and mixed in 4:1 ratio and ensiled in silo pits of 1.5 m³ dimension. After 45 days, the silage was evaluated for nutritional quality and feeding value for milch cows.

Silage was excellent with greenish yellow colour and a pleasant aroma. Biochemical analysis revealed pH 5.22, ammonia-N 0.175, total nitrogen 1.51, acetic acid 3.88%, lactic acid 3.24%, total acid 6.12% and NH3-N% of TN 11.64, L% R value 53 and Fleig index 64, C. P. 9.46%, Ether extract 2.24%, CF 31.03%, TA 11.56%, water soluble carbohydrate 3.55%, NDF 58.80%, ADF 45.03%, lignin 14.27%, silica 3.42%, hemicellulose, 13.17% and cell content 41.20%. The DM intake was 3.26 kg/100 kg b.w and average milk yield was 5.18 litre/day/animal.

Ensilage of sorghum var. PC-6

Sorghum var. PC-6 at flowering stage was chaffed, wilted and ensiled in silo pits
The chemical composition of fresh forage was: CP 4.8%; WSC 8.24%; NDF 73.43, ADF 43.22% lignin 2.47%, silica 2.04% cell content 26.57% and hemicellulose 30.21.

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)

Nutritive value of (NB-21) + Leucaena

Feeding trial on growing crossbred calves was conducted to evaluate green Napier (NB-21) + *Leucaena leucocephala* (1:1). Twelve cross-bred calves were divided into groups (6 each). The group-I (average body weight 132 kg) was fed dry grass and 1 kg concentrate mixture (control) while the group-II (average body weight 116 kg) was fed *ad lib* Napier + *Leucaena*. After one month, preliminary feeding period, a digestion metabolism trial was conducted on 3 calves in each group. Digestibility coefficient of two rations is given in (Table 17). DM intake (kg/100 kg body weight) in experimental group was 2.58 compared to control 1.79 and DCP and TDN intakes (g/h/d) were 218.5 vs 149.8 and 1710 vs 1210. Digestibility coefficients (%) of proximate principles were higher in experimental group and the same was true with NDF, ADF and CC digestibility. Experimental group also retained more nitrogen than control 25.3 vs 17.7 g/day. Inspite of higher digestibility and nitrogen balance, daily body weight gains were less in experimental group (260 g) than control (430 g). The calves of experimental group developed ulcers on the tongue and showed profuse salivation which was attributed due to mimosine (1-3%) in *Leucaena* (coppicing growth), DCP and TDN contents of control and experimental groups were found to be 6.30 vs 7.31 and 50.77 vs 57.07 respectively.

Table-17: Digestibility coefficient of nutrients in Napier (NB 21) + *Leucaena leucocephala* green forage compared to control.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>DM</th>
<th>OM</th>
<th>CP</th>
<th>CF</th>
<th>EE</th>
<th>NFE</th>
<th>NDF</th>
<th>ADF</th>
<th>CC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry grass + concentrate</td>
<td>59.1</td>
<td>50.7</td>
<td>70.0</td>
<td>46.9</td>
<td>42.1</td>
<td>49.5</td>
<td>53.5</td>
<td>42.3</td>
<td>41.1</td>
</tr>
<tr>
<td>Napier + <em>Leucaena</em></td>
<td>64.4</td>
<td>64.3</td>
<td>72.1</td>
<td>61.3</td>
<td>44.5</td>
<td>63.8</td>
<td>63.9</td>
<td>61.5</td>
<td>65.0</td>
</tr>
</tbody>
</table>
Nutritive value of dry grass *ad lib* + green berseem (30 kg) in milch cow

Feeding trial on lactating cows (average body weight 383 kg) yielding on an average 6 kg milk was conducted. The cows were offered 30 kg of green berseem and dry grass *ad lib* per head per day. Digestion trial was conducted after a period of one month to assess its nutritional value for milk production. The feeding trial continued for a period of three months. The ration provided the nutrients more than what is required and digestibility coefficients were high and the ration was highly nutritious. The milk yield was maintained (6 kg/h/d) throughout the period and animals improved their body weight. The cows consumed dry matter @ 2.56% of body weight and DCP and TDN (g/h/d) were 1164.4 and 5920, respectively. The rations supplied 11.86% DCP and 60.47% TDN.

Nutritive value of dry grass treated with 4% urea and 3% calcium hydroxide

Dry grass was chaffed and treated with 4% urea and 3% calcium hydroxide dissolved in 50 litres of water and solution was sprayed on the dry grass layers. After the treatment it was ensiled in silo and sealed. After one month the silo was opened and fed to the growing calves. After 20 days of preliminary feeding the digestion trial was conducted. Dry matter (% of body weight) DCP and TDN intake (g/h/d) were 3.17, 183.75 and 1670 respectively. Digestibility coefficients of the nutrients were also fairly high except for NFE end CC. The treated dry grass provided 5.25% DCP and 47.80% TDN indicating much improvement of dry grass.

### 2.2 Evaluation of protein quality of forages and grasslands

**Nutritional evaluation of mixed pastures for daily cows.**

(P. Kumar and P. K. Jayan)

Mixed pastures of *Cenchrus* and *Stylo* (1:1) and *Bothriocloa* + *Stylo* (1:1) were evaluated for milk production under stall feeding conditions and the data of intake and digestibility of dry matter was reported earlier and other data are summarised in (Table-18).

Perusal of the data shows that mixed pastures supply higher levels of DCP and TDN and *Bothriocloa* + *Stylo* mixture supplied lower level of DCP but higher level of TDN as compared to *Cenchrus* + *Stylo* mixture. The cows produced @ 3-4 litres milk/day during the trial period.
Table 18: Nutrient consumption and utilization by milch cows

<table>
<thead>
<tr>
<th>Feed</th>
<th>Dry matter</th>
<th>Crude protein</th>
<th>Ether extract</th>
<th>Total Carbohydrate</th>
<th>DCP (%)</th>
<th>TDN (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intake (kg)</td>
<td>Intake (kg)</td>
<td>Intake (kg)</td>
<td>Intake (kg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pure Cenchrus</td>
<td>8.86</td>
<td>0.34</td>
<td>0.18</td>
<td>7.44</td>
<td>1.98</td>
<td>47.15</td>
</tr>
<tr>
<td>Cenchrus + Stylo (1:1)</td>
<td>9.04</td>
<td>0.57</td>
<td>0.18</td>
<td>7.26</td>
<td>3.79</td>
<td>51.44</td>
</tr>
<tr>
<td>Bothriocloa + Stylo (1:1)</td>
<td>8.92</td>
<td>0.48</td>
<td>0.16</td>
<td>7.62</td>
<td>3.51</td>
<td>61.71</td>
</tr>
</tbody>
</table>
Evaluation of protected forage protein for calves

(P. Kumar)

Berseem hay protected with formaldehyde (1%) was mixed with dry grass (3:1) and evaluated for growing calves with untreated berseem hay as control. Experimental animals were given crushed cat grain @ 1 kg/animal/day. It was reported that the average dry matter intake of control and experimental groups was 1.835 kg and 1.521 kg, respectively. The digestibility coefficient of dry matter for the respective groups was 42.75% and 53.68%. The formalin treatment depressed voluntary intake of dry matter, crude protein, ether extract and total carbohydrates but improved digestibility of protein from 71.67% to 75.83% and that of total carbohydrates from 47.61% to 56.00%. This in turn increased the DCP content from 5.87% to 6.36% and TDN from 50.90% to 58.24%, respectively. Due to improved utilization of protein as well as carbohydrates the treated group recorded growth rate of 345 g/day as compared to 308 g/day in the control group.

Nutritional evaluation of Iseleima based pasture and hay for growing calves

(P. Kumar and B. K. Trivedi)

Eight calves weighing between 160-200 kg were selected and divided into two groups at random on the basis of their body weight. The control group was maintained exclusively on grazing and the other group was offered barley grain fortified with urea (2%) to ensure better and balanced nutrition @ 1 kg/animal/day. All the animals were grazed for 6 hours daily for 75 days. Both the groups recorded satisfactory growth rates. The weight gains of the control and the grain supplemented groups were 413 and 446 g/day, respectively.

The hay prepared from above pasture is being evaluated on the same calves under stall feeding conditions.

2.7 Investigations on health problems of the farm animals incidental to forage feeding system

(J. Prasad)

Leucaena toxicity in goats

Nineteen cases of frequent illness in Barbari goats fed with different proportions of L. leucocephala were investigated for diagnosis and treatment.
Clinical examination revealed anorexia, increased salivation, weakness and erosive lesions in the buccal cavity. Rumen movements and pH were nearly normal. In one case both thyroids were enlarged and palpable. Urine in most cases showed the presence of mimosine/DHP. In few cases excessive crystals of calcium carbonate were seen in the urine. Based on these observations it is concluded that mimosine toxicity does occur in goats although symptoms are less pronounced.

Therapy with oral thyroxine and a mixture of ferrous sulphate, copper sulphate and zinc sulphate alleviated the symptoms in goats on *Leucaena* mixed diet without withdrawal from the feed.

**Leucaena toxicity in Rabbits**

Two cases of *Leucaena* toxicity were observed in rabbits. Symptoms were characterized by marked alopecia over chest, abdomen and tail. Withdrawal of *Leucaena* feed resulted into development of hairs.

**Histopathological studies on *Leucaena* toxicity in lambs**

(This work was done in collaboration with Dr. O. P. Paliwal, S-3 (Vet. Med.) in IVRI, Izatnagar)

Histopathological studies of tongue, liver, gall bladder, kidneys, urinary bladder, thyroids and spleen revealed complete disquamation of epithelium with necrosis with streptococi in tongue, congestion, haemorrhages with necrosis of hepatic cells around central vein and early fatty changes in liver, disquamation of epithelium in gall bladder; proliferation of lining epithelium in the acine of thyroids; congestion of glomeruli, tubular degeneration and intertublar haemorrhages in kidneys; congestion and hyper-plasia in spleen. The lesions were suggestive of toxic effects on these organs.

**Detection of phyto-haemagglutinin in *L. leucocephala* leaves**

Phyto-haemagglutinin, another toxicant was detected in 1 aves of *L. leucocephala* for the first time in India. Its significance in clinical cases is to be studied.

**Contracted flexor tendons in a cross-bread calf**

A case of contracted flexor tendon of both fore limbs was recorded in a new born cross-bred calf. Occurrence of such cases is very low. Medical and surgical therapy remained futile in this case.
Health coverage

Clinical: In total 1678 (new cases-408, old cases-1270) cases were attended for diagnosis and treatment. Twelve autopsies were performed.

Preventive: Preventive deworming (133), dipping (218), immunization (115), WSMT (20), Brucella testing (10) and TB/JD (15) examinations were carried out.

2.8 Nutritional evaluation of legume forages with special reference to *Sesbania aegyptica*

(A. Rekib, A. P. Singh and E. Sebastien J.N.)

Evaluation of pasture forages with special reference to *S. aegyptica*

Four legume forages (viz., *S. aegyptica, L. leucocephala; S. hamata* and *S. humilis*) and nine grasses (viz., *D. annulatum, C. fulus, I. laxum, H. contortus, C. ciliaris, S. nervosum, P. maxicum, S. sphacelata* and mixed natural grasses) were collected in the month of September, 1986 and were analysed for CP, NDF, ADF, lignin, ash, acid insoluble ash and in vitro dry matter digestibility. Amongst the leguminous forages *S. aegyptica* was found to contain maximum amount of CP (20.03%) and in vitro digestible dry matter (87.8%).

Amongst the pasture grasses *S. sphacelata* contained maximum CP (13.75%) and in vitro digestible dry matter (67.77%) and minimum NDF (67.5%).

Estimation of Aminoacid from *Sesbania* seed

The method of two dimensional paper chromatography for the estimation of amino-acids is being standardised.

2.9 Micronutrients in pastures and forage crops and their utilization

Trace mineral status of natural grazing area of Bundelkhand region

(K. S. Ramchandra, R. K. Tyagi, P. Kumar and B. K. Trivedi)

The herbage samples collected from the natural grazing areas of Lalitpur and Tikamgarh districts of the Bundelkhand region were analysed to assess the levels of important trace minerals and proximate principles. Iron was adequate (Lalitpur-67.33 ppm, Tikamgarh 116.51 ppm) but zinc was low (Lalitpur-10.54 ppm, Tikamgarh-13.65 ppm) copper content was low (6.865 ppm) in the herbage samples of Lalitpur district only. Concentration of proximate principles is detailed below:
Crude protein 3.20—4.49%, Total ash 7.07—12.48%, Silica 6.63—9.12%, NDF 66.47—74.73%, ADF 39.23—47.17%, Lignin 6.07—8.79%, Cellulose 26.80—38.80% and Ether extract 1.05—1.90%.

The herbage samples from the natural grazing areas of the Bajna and the Central Block of the Central Research Farm of IGFRI Jhansi collected at monthly intervals and were analysed for proximate principles (CP, EE and CF) and trace elements (Copper, Zinc, Iron and Cobalt). The results are presented in (Table-19). The samples from Bajna block had higher copper content as compared to the Central Block. The zinc content was below the normal levels whereas iron was adequate in both the areas. No appreciable change in the trace mineral levels in different seasons was observed.

Table-19 ; Nutritional composition of natural pastures of the Central Research Farm of IGFRI.

<table>
<thead>
<tr>
<th>Location</th>
<th>CP (%)</th>
<th>EE (%)</th>
<th>CF (%)</th>
<th>Cu (ppm)</th>
<th>Zn (ppm)</th>
<th>Fe (ppm)</th>
<th>Co (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BAJNA BLOCK</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1.</td>
<td>4.56</td>
<td>1.70</td>
<td>33.45</td>
<td>5.87</td>
<td>14.56</td>
<td>72.56</td>
<td>0.07</td>
</tr>
<tr>
<td>2.</td>
<td>4.82</td>
<td>2.15</td>
<td>31.86</td>
<td>16.56</td>
<td>15.81</td>
<td>86.12</td>
<td>0.07</td>
</tr>
<tr>
<td>3.</td>
<td>4.82</td>
<td>2.23</td>
<td>32.72</td>
<td>13.51</td>
<td>17.85</td>
<td>88.32</td>
<td>0.08</td>
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<tr>
<td>4.</td>
<td>5.21</td>
<td>1.98</td>
<td>33.00</td>
<td>6.58</td>
<td>23.52</td>
<td>102.48</td>
<td>0.06</td>
</tr>
<tr>
<td><strong>CENTRAL BLOCK</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>4.32</td>
<td>1.25</td>
<td>36.52</td>
<td>10.87</td>
<td>15.21</td>
<td>68.96</td>
<td>0.06</td>
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<tr>
<td>2.</td>
<td>4.65</td>
<td>1.15</td>
<td>34.20</td>
<td>9.56</td>
<td>22.53</td>
<td>101.38</td>
<td>0.09</td>
</tr>
<tr>
<td>3.</td>
<td>3.84</td>
<td>1.85</td>
<td>38.56</td>
<td>7.52</td>
<td>13.51</td>
<td>98.21</td>
<td>0.07</td>
</tr>
<tr>
<td>4.</td>
<td>3.85</td>
<td>1.87</td>
<td>36.13</td>
<td>7.18</td>
<td>14.17</td>
<td>61.83</td>
<td>0.07</td>
</tr>
</tbody>
</table>
### 3.2 Economic exploitation of weeds

(B. K. Ehadoria, R. K. Gupta and V. C. Pachauri)

**Investigation on *Antirhinum orentium***

*Antirhinum orentium* is a commonly growing weed in crop fields. In continuation with the earlier work, further chemical investigation were undertaken to assess the possibility of its utilization as a livestock feed. The benzene soluble extract on its column chromatography on sigel column could yield only *B*-sitosterol-*D*-glucoside which was identified as usual by co-tile pure sample. The ethyl acetate soluble fraction after removal of solvent was digested with methanol. The methanol soluble part was chromatographed on sigel column and eluted with solvents in increasing order of polarity resulting into following crystalline compounds.

- **Free Lut olin**: Obtained as yellow product on elution with *EtOAc : MeOH*. Crystallised from excess of *MeOH* mp 300°. It gave red orange colour with Mg/HCl. R_{KBr}^{\text{max}} 3400, 1660, 1500, 1260, 1170, 1070, 940, 820, cm^{-1}. It formed an acetate (*NaOAc + AC_2O*)mp 224°. The identity of compound was established by comparision with authentic sample on TLC and mmp.

- **Luteolin glucoside**: Yellow micro-crystalline from *EtOH* mp 258°. It responded to Shinoda test and Moisch's test. On its acid hydrolysis it yielded an aglycone which was identified as Luteolin by mmp and Co-tile. The glucose was identified from hydrolysate by paper chromatography. Finally it was confirmed as glucoside of Luteolin. (The leaves of *Antirhinum orentium* did not show the presence of any toxic principle like saponin, HCN, oxalate, NO_3 etc.) The remaining alcoholic extract yielded a white deposition which was identified as Manitol - a sugar alcohol.

**Nutritive value of *Antirhinum orentium* for growing kids**

Four growing Barbari kids were offered *ad lib Antirhinum* weed (green at postflowering stage). The digestion trial was conducted to determine its nutritive value. The *Antirhinum* (an unconventional forage) is quite nutritive (DCP 7.51% and TDN 81.05%) and the digestibility coefficients of nutrients ranged between 73-90% and nitrogen retention (q/h/d) was also high (+5.48%).

**Investigation on *Sopubia delphinifolia***

Further work on chemical investigation of leaves of *S. delphinifolia* was undertaken.
The petroleum ether and benzene soluble fractions were chromatographed on silica gel column separately. The column chromatography of these fractions could yield only hentriacontane, B-sitosterol and B-sitosterol-\(\beta\)-glucoside.

Post graduate studies (Ph. D. Programme)

1. **Chemical constituents and nutritional quality of forage**

   (S. C. Gupta)

Chemical characterisation of *Brachiaria* spp.

(i) Petroleum ether soluble fraction (from alcoholic extractions of *Brachiaria decumben* leaves) was chromatographed over alumina. On elution with petroleum ether/ethyl acetate mixtures, sitosterol glucoside, triterpenoid ester and compounds pertaining to triterpenoid and sterol groups were isolated. Fractions from elution with methanol showed the presence of potassium nitrate.

(ii) Petroleum ether and benzene soluble fractions (from alcohol extraction of *Brachiaria dityoneura* leaves) were subjected to column chromatography over alumina and silica gel. More than 100 fractions collected in each case, using petroleum ether/hexane/petroleum ether-benzene mixtures as eluting agents compounds isolated from petroleum ether soluble fraction, showed the presence of triterpenoids and sterols. Ethyl acetate soluble fraction (from the alcoholic extraction of *Brachiaria dityoneura* leaves) on alkaline hydrolysis yielded an acidic compound.

Chemical constituents in *Desmanthus virgatus*

An unsaturated compound (mp=110°C: acetate, mp 61°C) was isolated from the alcoholic extractions of *Desmanthus virgatus* seeds.

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

   (N. C. Verma)

Three metabolism trials were conducted on crossbred lambs during 1986. The feeding regimes were as under.
A - *Cenchrus ciliaris* grass hay (100%)

B - *C. ciliaris* hay + *S. hamata* hay (75+25%)

C - *C. ciliaris* hay + *S. hamata* hay (50+50%)

D - *C. ciliaris* hay + *S. hamata* hay (25+75%)

E - *Stylosanthes hamata* hay (100%)

The lambs were maintained on test herbages for 270 days under stall feeding conditions. No concentrate was given till the completion of the first metabolism trial of 70 days. Thereafter 120 g of concentrate mixture and 5 g mineral mixture were given to each lamb daily during the second and third trials. The body weight of lambs were recorded at 10 days intervals and the body measurements were recorded at monthly intervals.

The carcass characteristics were assessed at the end of the feeding trial (after 270 days). Three lambs from each group were slaughtered after being fasted for 15 hours to determine the dressing percentage and meat, fat, bone ratio.

The crude protein of the ration in groups A, B, C, D and E were 6.34, 8.17, 9.22, 10.55 and 12.15 per cent, respectively. The DCP content was 3.10, 5.64, 6.46, 8.04 and 9.08% during the first trial, 4.70, 5.57, 6.79, 7.69 and 8.82% during the second trial and 4.23, 5.69, 6.64, 7.78 and 9.03% during the third trial in group A, B, C, D and E, respectively. The TDN contents were 50.92, 53.22, 53.08, 54.69 and 56.58% during the first trial, 58.41, 60.73, 60.37, 62.12 and 65.79% during the second trial and 59.28, 61.57, 62.97, 64.74 and 66.16% during the third trial in group A, B, C, D and E, respectively.

The average daily gains recorded during the first trial period were lower than those observed during subsequent trials when the animals were offered concentrate supplements. With the increase in protein level the animal performance was better in the three experiments. The dressing percentage varied between 35.82 to 38.64. The bone meat ratios were 1:3.17, 1:3.23, 1:3.11, 1:5.03 and 1:2.89 in group A, B, C, D and E, respectively.

The physiological indices and haematological attributes were within the normal range for all the experimental lambs during whole feeding period.

3 Studies on *Leucaena* based feeding systems for increased goat production

(V. S. Upadhyay)

Forage yield and quality of *Leucaena leucocephala* cv. Cunningham Line–3 at intervals
of 30, 45 and 60 days harvest in different seasons were studied. Two different levels of *Leucaena* supplementation i.e. 4% and 6% of live weight (fresh weight basis) which was expected to be approximately 50 and 75% of total dry matter intake with *ad lib* feeding of dry grass, were compared with berseem hay + dry grass (75:25).

The continuous feeding trial on growing kids was conducted for three months with three treatments viz. (i) *leucaena* + grass (75:25 on DM basis) *ad lib*  (ii) 100 g energy rich concentrate per head plus above mentioned forage *ad lib* and (iii) 200 g concentrate per head plus forage *ad lib*. The data are being synthesized and will be reported in due course of time.
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. Stngh, V. J. Stivanakar and S. M. Mishra)

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

This experiment comprising 3 spacings (50 x 30, 50 x 40 and 50 x 50 cm) and 4 levels of nitrogen (0, 40, 80 and 120 kg N/ha) was conducted in randomized block design during winter 1986-87.

Turnip planted at spacing of either 50 x 30 or 50 x 40 cm produced 27 to 35% higher seed 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 was 31.7 and 6.9% over control and 40 kg N/ha, respectively. Spacing and nitrogen interaction was not significant.

Turnip planted at closer spacings of either 50 x 30 cm or 50 x 40 cm had the higher aphid population than the one planted at wider spacing of 50 x 50 cm and that the levels of nitrogen viz; 120 and 80 kg/ha attracted greater number of aphids than the lower level and the control. Control measures employed revealed that, at least three sprays of endosulfan 35 EC at 0.075% at 15 days interval starting from the first week of February protected the crop effectively by arresting the aphid population at its minimum (10-42.7 aphids/plant).

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

An experiment comprising 3 varieties (IFC-8401, IFC-8402 and NP-3) phosphorus levels (0,40 and 80 kg P₂O₅/ha) and 2 levels of potassium (0 and 40 kg K₂O/ha) was conducted in split plot design at IGFRI, Jhansi during rainy season of 1987.

Among three varieties of cowpea (IFC 8401, IFC-8402 and NP-3), NP-3 was the highest seed producer. The seed production efficiency of IFC-8401 was nearly equal to IFC 8402. Application of phosphorus was beneficial to the crop and seed yield increased by 85.5%
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 level.

Response of cowpea to phosphorus application under varying dates of seeding and potassium levels

An experiment comprising 3 dates of sowing (July 10, July 30 and August 19), 3 levels of phosphorus (0, 40 and 80 kg P₂O₅/ha) and 2 levels of potassium (0 and 40 kg K₂O/ha) was conducted in split plot design during rainy season of 1987.

July sown crop performed better than August sown. Application of 40 kg P₂O₅/ha improved the seed yield by 34% but application beyond 40 kg could not bring additional improvement. Application of potassium was not beneficial to either early or to late sown cowpea.

2.2 Agronomical investigations in pasture legume seed production

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

Effect of foliage applied nutrients on seed yield and quality of siratro

A field experiment was conducted to evaluate the influence of KNO₃, P₂O₅, ZnSO₄, CuSO₄ and borax each at the rate of 2 kg/ha applied on foliage in single and in combination on seed yield.

Out of the single nutrients, KNO₃ which yielded 64 kg, proved superior to CuSO₄, ZnSO₄, borax and P₂O₅ in seed production and its effectiveness was further increased when it was applied in combination with CuSO₄. The increase in seed yield with this combination was more than double of the control (33.9 kg/ha).

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

(R. K. Pandey)

Multivariate evaluation to select oat ideotypes having maximum seed and fodder production potential

This was the second year of the experiment. From fodder production point of view, multicut varieties are preferable and could be evaluated for fodder-seed production systems. Therefore, 14 oat genotypes, viz. JHO-810, OS-6, OS-96, OS-121, OL-9, OL-88, OL-113, OL-125, UPO-136, UPO-205, UPO-209, UPO-210 and oat Kent were evaluated in comparison to the oat, ICFRI-3021. The objective of the study was to select better varieties for fodder-seed production systems.

UPO-209 and Kent showed better performance in seed production over IGFRI-3021. However, forage production values did not differ. The oat cultivars JHO-810 and OL-9 appeared to be at par with IGFRI-3021 in respect of both dry fodder as well as seed yield. The variety OL-9 produced significantly higher dry forage yield but low seed yield as compared to IGFRI-3021.
Evaluation of seed cowpea based fodder-seed production systems

This was the second year of the study. The objective of the study was to work out the promising fodder-seed production system with an additional yield of fodder in the mid of the season. 50 cm apart row crop of seed cowpea (NP-3) was intercropped with an alternate row crop of fodder cowpea (HFC-42-1), clusterbean (IGFRI-212) and black gram in between each two rows of seed crop. In addition, two more treatments of cowpea (NP-3) were sown at 25 cm row spacing. In one treatment, the alternate rows and in the next, each fourth row, alternatively were harvested for fodder and left over rows were maintained for seed production. For comparison, four treatments of seed-cowpea (NP-3) were also added. In these four, two were of broadcast sowing with 20 kg and 40 kg seed rate/ha and rest two were line sowings at 25 cm (40 kg seed rate/ha) and 50 cm (20 kg seed rate/ha) row spacings. These nine cropping system were laid out in the randomized block design with three replicates. The fodder rows were harvested at 40 days crop growth.

The maximum green and dry matter yields of fodder were obtained where the 50 cm apart row crop of seed cowpea NP-3 (20 kg seed/ha) was intercropped with an alternate row crop of fodder cowpea HFC-42-1 (20 kg seed/ha). This fodder-seed production system yielded 93.3 and 11.3 q/ha green and dry matter yields of fodder, respectively and was found superior over the other treatments. In dry matter yield, this treatment was closely followed by the crop combination where the fodder crop of black gram replaced the fodder cowpea (HFC-42-1) in the above system. The effects of treatments on seed yields could not be evaluated because of the poor seed setting in the abnormal season.

2.4 Agronomic investigation for increasing seed yield in grasses

(G. K. Dwivedi)

Studies on different foliage applied plant nutrients for seed production in Cenchrus ciliaris

This field experiment was continued for the second year to evaluate the significance of foliar nutrients on the biomass production and seed yield of Cenchrus ciliaris IGFRI-S-59-1. For this purpose the treatments viz. KNO₃, Urea, S. S. P., ZnSO₄, MgSO₄ applied singly @2 kg/ha and the combination of KNO₃+Urea, KNO₃+ZnSO₄, Urea+ZnSO₄, Urea+S.S.P. along with control were tried. These nutrients were sprayed by dissolving them in 600 l water/ha at 50% flowering stage of Cenchrus ciliaris. Application of KNO₃ gave highest seed yield (67.01 kg/ha) followed by urea (63.82 kg/ha). When KNO₃ was combined either with urea or ZnSO₄ it increased the seed yield 5 to 6.5% over the application of KNO₃ alone. The forage yield was maximum with the application of KNO₃+Urea (126.4 q/ha) followed by Urea+S.S.P (103.3 q/ha).
Response of *Desmodium tortuosum* strains legume on nitrogen economy of seed production of *Setaria sphacelata*.

The experiment was repeated this year to evaluate the nitrogen economy by legume association and its reflection on biomass production and seed yield potential of *Setaria sphacelata* cv. Nandi on the basis of nitrogen treatments. The association of *Desmodium tortuosum* (1565 and 1568) increased seed yield of *Setaria sphacelata* over its monoculture condition and the effect of these legume association was at par with 40 kg N/ha. Other strains of *Desmodium* performed equivalent to 20 kg N/ha. Moreover, application of 40 kg N/ha gave highest biomass production (223.1 q/ha). However, the association of *Desmodium tortuosum* (1565 and 1568) brought out the biomass production of mixed herbage (174.8 q/ha and 176.2 q/ha) at par with the level of 30 kg N/ha (198.8 q/ha). All the treatments gave significantly higher biomass production over control (82.3 q/ha) except 10 kg N/ha treatment (101.1 q/ha). Introduction of *Desmodium tortuosum* (1565 and 1568) could thus be used as an alternative in saving 30 kg N/ha.

Nitrogen economy by legumes association in *Panicum maximum* for seed production

Five perennial legumes (*Desmanthus virgatus* *Sesbania aegyptiaca*, *Macroptelium autropurrenum*, *Desmodium tortuosum* and *Stylosanthes hamata*): Which were sown during the previous year were continued and five nitrogen levels (0, 10, 20, 30 & 40 kg N/ha) were applied to evaluate the nitrogen in *Panicum maximum*.

Among the legumes as intercrops, the association of *S. hamata* was most promising for seed yield (72.2 kg/ha) which was at par with 0 kg N/ha (74.7 kg/ha). The performance of *Macroptelium autropurrenum* (63.3 kg/ha) and *Sesbania aegyptiaca* (62.4 kg/ha) was equivalent to 30 kg N/ha in reaping the seed yield (65.1 kg/ha) of *Panicum maximum*. All the treatments gave significantly superior performance over control (monoculture) (34.3 kg/ha) in reaping the seed yield of this grass.

The biomass production of the herbage was highest with the introduction of *Desmodium* (383.9 q/ha) and it was at par with 40 kg N/ha.

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

This field experiment was conducted during the year to evaluate the significance of foliar application of nutrients on the quality, seed production and biomass yield of *Setaria sphacelata* cv. Nandi. The treatments viz. KNO₃, Urea, S.S.P., MgSO₄ and ZnSO₄ were applied singly and in combination and these were compared with control.
Foliar application of KNO₃ was significantly superior to ZnSO₄ (31.1 kg/ha), SSP (27.4 kg/ha) and MgSO₄ (24.8 kg/ha). Its effectiveness further increased when sprayed in conjunction with urea or SSP.

1.5 Seed yield of sorghum and lucerne in relation to supply of boron at anthesis

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

Effect of micronutrients on lucerne

An experiment to study the effect of different levels of boron in split applications on seed production in lucerne was initiated in pots. The treatments were to be introduced at and after 25 per cent flowering but abnormal symptoms of drying just before the start of reproductive phase were observed. The first parts to be affected were the tips of the stem and the youngest leaves on top. The tops wilted, dried and curled within three four days. Slowly the drying progressed towards the bottom through stem, decayed and became brown and brittle. The lower portion of the plant still remained green and the leaves on lower portion also did not show any symptom of drying. At this stage, the nature of the study was changed in hope to get a clue to the reasons of abnormal drying of plants. The pots were grouped in two categories (25% and more than 25% plant area affected and different micronutrients-(Mn, Fe, Zn, Cu and B) were sprayed to study their effect on further spread and/or resistance to symptoms, recovery by plants and their overall effect on flower and seed production. The concentration of micronutrients sprayed was as under. However, in case of MnSO₄, ZnSO₄ and CuSO₄ the acidity was neutralized by adding lime (5% of the micronutrient salt).

<table>
<thead>
<tr>
<th>Micronutrients</th>
<th>Concentration used</th>
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<tbody>
<tr>
<td>Mn</td>
<td>1% solution of MnSO₄</td>
</tr>
<tr>
<td>Fe</td>
<td>4% solution of FeSO₄</td>
</tr>
<tr>
<td>Zn</td>
<td>0.5% solution of ZnSO₄</td>
</tr>
<tr>
<td>Cu</td>
<td>0.25% solution of CuSO₄</td>
</tr>
<tr>
<td>B</td>
<td>0.25% solution of Borax</td>
</tr>
</tbody>
</table>
The results revealed that Cu was most effective in checking the further spread of the abnormality followed by Fe. While in other treatments, seed formation did not take place.

**Effect of boron levels on seed production of jowar varieties**

An experiment comprising 4 levels of boron (0, 2, 4 and 6 kg borax/ha), two methods of boron application (Full dose at flower initiation and three splits during anthesis and two varieties (PC-6 and HC-136) was conducted in randomized block design during rainy season of 1987.

Seed yield of sorghum increased with each increase in the level of foliage applied boron up to 4 kg borax/ha. Split application of boron proved better than full dose. PC-6 was more responsive to boron than HC-136. The highest yield was recorded in PC-6 variety sprayed with 4 kg borax/ha. The contribution towards increase in seed yield was made by increased number of seeds per panicle and by heavier seeds.

**2.1 Seed borne diseases and their control in forage crops**

(S. N. Singh)

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

Thiram, Dithane M-45 and Bavistin @ 0.25 g per kg seed as alone and their combinations both as dry seed treatment as well as spray @ 0.25% were tried in var. NP-3. The combined effect of Bavistin+Dithane M-15 proved best for controlling seedling mortality and by *Macrophomina phaseolina*, *Fusarium semitectum* and *Fusarium equisetii* and for producing higher seed yield over control.

**Evaluation of fungicides against head mould (Fusarium and Curvularia spp.) and other leaf spot diseases in sorghum seed crop.**

A field experiment comprising seed treatment with Bavistin, Thiram and Dithane M-25 as alone and their combinations @ 0.25 g per kg seed each and later on their subsequent one spray at dough stage was done on jowar HC-136. The seedling emergence was highest in Bavistin+Dithane M-45 treatment due to minimum pre and post-emergence mortality over the control. Later on, their subsequent one spray at dough stage in combination with Endosulfan 0.075% reduced the incidence of grain mould caused by *Curvularia lunata* and *Fusarium moniliforme* and sorghum leaf folder (*Macrasmia trapezolii*) as well as leaf blights. This resulted in increased seed yield (62%) over control.
Studies on control of seed borne diseases especially *Fusarium* rot in berseem

Amongst the fungicides tried in variety IGFRI-91-1, Bavistin+Thiram @ 0.3 g/kg seed as dry and wet seed treatments reduced the seedling mortality (0.33%) caused by *Fusarium oxysporum*, and increased (58%) the plant stand which ultimately increased the average seed yield by 78% over non treated seeds.

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

An in vitro experiment was conducted on 400 random samples of sorghum HC-136 seed collected from different fungicidal treated plots for rating grain mould incidence and its effect on germination.

The occurrence of *Curvularia lunata* and *Fusarium moniliforme* were predominant (upto 56%) in nontreated seeds whereas seeds obtained from Bavistin+Dithane M-45 sprayed heads showed reduced range of moulded grain (5.6 to 11.2%).

The moulded grains impared the germination producing abnormal seedlings depending on the frequency of occurrence of *Curvularia* and *Fusarium* isolates and their complex with other pathogens like *Helminthosporium* spp.

3.1 Studies on insect pests and pathogens in seed storage

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

Effect of different types of containers and seed protectants on the incidence of store pests

Cowpea var. IGFRI-450 and sorghum var. HC-136 with 11.5-12.5% moisture content were treated with 1. Malathion dust @ 1 g/kg of seed; 2. Neem (*Melia azadirachta*) leaf powder at 1:100 parts of seed+malathion (as in-1) and; 3. Arappu (*Albizia amara*) leaf powder at 1:100+malathion. In another set, 100 g of treated as well as untreated seeds were separately placed in: 1. plastic containers; 2. metal bins; 3. gunny bags and 4. 700 guage polythylene bags and stored at room temperature. Samples from each treatment were drawn before storage and at monthly intervals after 3 months of storage and the seeds were tested for germination at 25±2°C.

Among the containers, polythylene bags were the best for seeds storage followed by metal bins and plastic containers with and without treatment for 6 months and there after. Gunny bags proved unsafe as viability of seeds declined after 5 months of storage irrespective of seed treatment. Malathion alone or in combination with neem or arappu leaf powder maintained viability of both cowpea and sorghum seeds.
In another experiment, where 5 pairs of *Callosobruchus chinensis* in cowpea and 5 pairs of *Sitotroga cereaTella* in sorghum, were released, percent seed damage in gunny bags was as high as 90% compared to 41-50% in other containers without treatment. The seeds treated either with malathion alone or in combination with neem or arappu leaf powders showed a negligible (below 90%) seed damage in gunny bags and less than 5% in other containers in both cowpea and sorghum. All the treatments were superior to control.

All the seeds treated with fungicide @ 0.25 g per kg seed maintained initial viability even after 8 months of storage, while untreated seeds lost their viability to a greater extent. Germination and seedling vigour was least affected in Bavistin + Dithane M-45 and Bavistin + Thiram treated seeds in sorghum and cowpea seeds, respectively, when stored at 10% moisture content either in sealed plastic jars or in 700-gauge double layered sealed plastic envelopes. The occurrence of storage fungi like *Fusarium*, *Aspergillus* and *Curvulatia* spp. was common to both cowpea and sorghum seeds.

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

Two sets of cowpea seeds (var. NP-3) sun-dried to 10 and 12.5% moisture levels and one with and the other without neem leaf powder mixed at 1:100 parts of seed were packed in plastic bottles (200 seeds/bottle) and kept undisturbed in BOD (20±2°C) and the other at room conditions. A bottle from each set was taken out for observations at regular intervals of 3, 4, 5, 6 and 7 months to study insect pest infestation and seed viability.

The viability declined (25-45%) sooner in the seeds stored at the combination of 12.5% moisture and room temperature as compared to the combination of 10% moisture and 20±2°C temperature (10-20%). There was a gradual increase (10-11.5 and 12-14.5%) in the moisture content of the seed stored at room temperature at the end of each interval. This trend might have affected the viability and rendered the seed vulnerable to pest attack. Resultantly, a small population of the bruchids (*Callosobruchus chinensis*) was noted in the set run at high moisture seeds kept at room temperature only at the end of 4 month interval indicating the presence of viable eggs on seeds prior to storage and their hatching at the slightest increase in the seed moisture content. Other sets with or without neem leaf powder run either in the BOD incubator or at room temperature did not have the pest population. Thus, the seed having moisture content between 10 and 11.5% stored at either conditions and with or without neem leaf powder did not favour the pest population except in case of seeds with higher moisture content of 12.5% stored at room temperature. It was further observed that neem leaf powder helped in maintaining the viability of seed even at the end of 7 months.

Higher percentage of storage fungi was isolated in seed lots kept at 12.5% moisture content at room temperature in comparison to 8.5% moisture content in both cowpea and sorghum.
Effect of organic material on insect pests and viability of cowpea and sorghum seeds in storage

Five pairs of *Collosobruchus chinensis* and *Sitotroga cerealella* adults were released in specimen tubes filled with 200 g disinfected (healthly) cowpea (var. IGFRI-450) and sorghum (var. HC-136) seeds treated with 3 concentrations of each petroleum ether extract of plant materials alongwith a control. Four sets were run separately for definite time intervals, say, I for 40, II for 80, III for 120 and IV for 160 days. At the end of each set of experiment the seeds were taken out and heated to kill the living insects. Dead insects were separated from seed and were counted. The seed was weighed and the damaged seeds were counted.

**Cowpea**

Root extract of *N. odoros* at 2% concentration was most effective (with the least seed damage 3.58%) followed by seed extract *C. tiglium* (3.87%), rhizome extract of *A. calamus* (4.74%), seed extract of *E. ribes* (4.78%), flower extract of *S. acmella* (5.30%), 4% kernel extract of *M. azadirachta* (5.64%), leaf extract of *O. kilimansaricum* (6.48%) and 2% *D. alba* (7.79%). Seed extracts of *P. glabra* and *A. squamosa* were least effective allowing more than 10% seed damage as compared to 5% mean seed damage in control after 160 days of storage.

*N. odoros* and *C. tiglium* offered effective protection to seeds up to 160 days while sweet lag, barberang, akarkara, neem and tulsi were effective up to 120 days and dhatura, karanj and sharifa lost their efficacy within 3 months of treatment. All the treatments were significantly superior to control. The seed damage was 19.14, 44.67, 61.41 and 78.39% by 40, 80, 120 and 160 days of storage, respectively.

**Sorghum**

Seed extract of *C. tiglium* at 2% concentration found to be the best treatments followed by *A. calamus*, *E. ribes*, *N. odoros* and *S. acmella* (all at 2% concentration) in protecting the seed from *Sitotroga cerealella* effectively (8.38%-9.80% seed damage) up to 160 days of treatment. Neem kernel extract at 4% concentration was effective up to 4 months; tulsi (4%), dhatura (2%) and karanj (4%) up to 3 months incurring below 10% seed damage while sharifa (4%) even at 80 days incurred more than 10% seed damage as compared to control where seed damage recorded was 24.24, 46.78, 64.40 and 78.03% by 40, 80, 120 and 160 days respectively. All the treatments were marked superior to control.

Germination tests conducted at the end of each interval revealed that the plant materials did not affect the viability of the seeds of cowpea and sorghum, adversely.
3.3 **Host-parasite relationship in fodder crops seed production**

(V. J. Shivanker)

**Screening of mustard germplasm against mustard aphid**

Twenty-nine germplasm of fodder mustard (IGFRI-'IM' series) viz. IM-1, -2, -3, -4, -5, -6, -9, -11, -13, -18, -19, -29, -30, -36, -37, -38, -39, -40, -42, -44, -45, -46, -49, -50, -51, -53, -54 and chinese cabbage were screened against the incidence of mustard aphid (*Lipaphis crysimi*).

There were no significant differences among the germplasm with regard to their tolerance to aphid incidence. However, a few of them viz. IM-5, 6, 9, 18, 19, 29, 38, 39, 40 51 and 54 appeared to be promising having only 5.29-9.90 aphids/4 cm-twigs while germplasm IM-45 and 30 were most susceptible with 40, 80 and 34.52 aphids/4 cm-twigs in their performance. Chinese cabbage was moderately tolerant to aphid attack, as compared to other germplasm.

Germplasm IM-13 gave the maximum seed yield (12 q/ha) followed by IM-4 (9.83 q/ha), IM-45 (9.39 q/ha), IM-38 (9.20 q/ha), IM-2 (9.11 q/ha) and IM-5 (9.00 q/ha) and belonged to tolerant and moderately tolerant categories. However, there were no significant differences amongst them.

**SPR-4 : DEVELOPMENT OF STANDARD TECHNIQUES FOR BREEDER'S SEED PRODUCTION WITH HIGH LEVEL OF GENETIC PURITY**

(O. P. Dixit and G. K. Dwivedi)

**Effect of some morphological attributes on seed yield in cowpea var. NP-3**

The variety NP-3 of cowpea was observed to have a mean plant height of 146.5 cm. It had 5.8 branches per plant on an average basis. On a single plant 14.9 pods with 214 seeds were obtained yielding 22.5 gram.

The seed yield per plant was significantly and positively correlated with number of pods and seeds per plant height was negative and non-significant. The number of branches had no correlation with seed yield. The correlation of plant height with number of branches number of pods and number of seeds per plant was highly significant but negative. The single regression equation indicated that per unit increase in number of pods and number of seeds per plant increased the seed yield by 2.56 and 0.17 g per plant respectively.

The plant height and number of branches had high positive direct effects on seed yield. The indirect effects of these two attributes on seed yield was negative indicating that their negative association with other attributes was real cause for their non significant association with seed yield. The effect of number of pods was mainly through the number of seeds per plant thus indicating that the selection for number pods and seeds per plant will lead to higher seed yields.
PPB-I. PHYSIOLOGICAL STUDIES IN FORAGE CROP IMPROVEMENT

1.1 Varietal screening and induction of drought tolerance in forages

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

A large number of cowpea cultivars were grown in field under rainfed conditions and were screened at incipient wilting stage for RWC, CSI and leaf temperature. On the basis of these parameters, it was found that varieties HFC-720, NP-3, UPC-6342, UPC-8488 UPC-9805 and UPC-1008 are comparative drought tolerant but there were not much variation in the leaf temperature.

Oat cultivar JHO-815 was grown in porcelain pots under various levels of soil moisture stress (0.2 to 0.8 atm). Growth observations, flowering and fruiting behaviour were recorded. Relative water content, proline accumulation and chlorophyll stability index were also determined at initial wilting stage. Data (Table-20) revealed that all the morphological characters including dry weight of shoot and grain yield reduced highly with induced soil moisture stress being maximum in 0.8 atm, but early flowering was recorded in comparison to plants maintained at lower atm. RWC in leaves decreased progressively while proline accumulation and CSI values increased under highly stressed condition (Fig. 3).

1.2 Salt tolerance in forages

(O. P. S. Verma)

Three Pennisetum hybrids viz. NB-21 and BN-82048 were planted in pots containing soil at five salinity levels (3, 5, 10, 15 and 20 Ece) simulated by the addition of saline water prepared with NaCl, CaCl_2 and Na_2SO_4 in the ratio of 7:2:1 in three replications. Plant height, number of tillers and leaves and dry weight of plant decreased with increased salinity levels, but proline accumulation increased with level of salinity. Reduction in dry matter yield/plant was more than 50% at 10 Ece onward in these hybrids. However, hybrid DL-379 was found to be tolerant against salinity with less accumulation of proline (110 mg/g fresh wt.).
Fig—3: Effect of soil moisture stress on oat cultivar JHO-815

Seeds of oat cv. IGFRI-3021 were soaked in 3 and 6% solutions of NaCl and CaCl$_2$ for 24 hrs. and sown in pots containing soils of increasing salinity levels (5, 10, 15, 20 Ece) along with normal soil as control. Unsoaked seeds were also sown in salt stress condition for comparison to soaked seeds with salt solutions. Leaves were analysed for free proline content at 50% flowering stage. Increase in proline content was recorded with the increasing levels of salinity. However, 36% of cad 2 accumulated less proline up to 15 Ece level as compared to other treatments. Higher seed yield was recorded at 5 Ece level through seed soaking in 3% of NaCl and 3 and 6% of CaCl$_2$.

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

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

Seeds of Siratro (Macroptelium autropurpureum L.) were sown in field in the randomized block designs. After establishment of plants, stands were maintained 25 cm
Table 20. Effect of soil moisture stress on morphological and physiological parameters of oat cv. JHO-815

<table>
<thead>
<tr>
<th>Plant Characters</th>
<th>Levels of Soil moisture stress (atm)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>0.2</td>
</tr>
<tr>
<td>Plant height (cm)</td>
<td>56.2</td>
</tr>
<tr>
<td>Tiller number</td>
<td>19.7</td>
</tr>
<tr>
<td>Leaf number</td>
<td>93.4</td>
</tr>
<tr>
<td>Leaf area (sq cm)</td>
<td>1460.1</td>
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<tr>
<td>Dry wt. in shoot (g)</td>
<td>107.8</td>
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<tr>
<td>Fertile tiller/plant</td>
<td>13</td>
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<tr>
<td>Ear length (cm)</td>
<td>27.3</td>
</tr>
<tr>
<td>No. of grain/plant</td>
<td>766.6</td>
</tr>
<tr>
<td>Grain wt./plant</td>
<td>17.0</td>
</tr>
<tr>
<td>1000 seed wt. (g)</td>
<td>22.2</td>
</tr>
<tr>
<td>Days to initial flowering</td>
<td>88</td>
</tr>
<tr>
<td>RWC (%)</td>
<td>84.4</td>
</tr>
<tr>
<td>Proline accumulation (mg/g fresh Wt.)</td>
<td>2.2</td>
</tr>
<tr>
<td>CS 1</td>
<td>1.5</td>
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</tbody>
</table>

Apart from line and 15 cm from plant to plant. Various concentrations of Vipul (commercial product of $\alpha$-NNA) were sprayed on the foliage after 35 days from sowing along with control. Flowering, fruiting and chemical constituents are recorded in (Table-21). Early flowering was noticed in treated series of plants (except 0.05%) in comparison to control. Total number of flowers formed on main shoot and seed setting percentage was enhanced with added doses of Vipul being maximum in 0.4%. Sugar content at collar region and in
flower also increased along with carotene content in leaves, but reduced considerably at highest concentration of the regulant. However, seed yield per plant was increased with lower doses of the chemical.

Table 21. Effects of Vipul ($\alpha$-NAA) on flowering, fruiting and chemical constituents in Siratro

<table>
<thead>
<tr>
<th>Character</th>
<th>Concentration (%)</th>
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<tr>
<td></td>
<td>Control</td>
</tr>
<tr>
<td>Days to initial flowering</td>
<td></td>
</tr>
<tr>
<td>Days to 50% flowering</td>
<td>68</td>
</tr>
<tr>
<td>No. of flowers/main shoot</td>
<td>80</td>
</tr>
<tr>
<td>Setting percentage</td>
<td>125</td>
</tr>
<tr>
<td>Sugar content in flower (mg)</td>
<td>18.1</td>
</tr>
<tr>
<td>Sugar content in collar region (mg)</td>
<td>4.50</td>
</tr>
<tr>
<td>Carotenoid content (mg)</td>
<td>0.54</td>
</tr>
<tr>
<td>Seed yield/plant (g)</td>
<td>25.0</td>
</tr>
</tbody>
</table>

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

(N. C. Sinha)

A pot culture experiment was laid out to evaluate the genotypic variability of 22 genotypes of cowpea. Early flowering genotypes were superior and gave higher seed yield than late flowering varieties. Early flowering varieties also had high NR activity, sugar, chlorophyll-a and chlorophyll-b including carotenoid than late flowering. Late flowering varieties comparatively had high sugar in collar region and low seed yield because of poor translocation.

A separate field trial was also laid out to see the physiological effects of pre-soaking seeds of cowpea cultivars with KNO$_3$ treatments. There was a differential response of KNO$_3$...
Table-22: Effect of pre-seed treatment of cowpea (5450, RG NP-3) with KNO₃ (2, 4 and 6%) on their physiological efficiency and seed yield

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Conc. of KNO₃</th>
<th>Seed yield q/ha</th>
<th>Concentration of water soluble sugar (g/100 g dry wt.)</th>
<th>Photosynthetic pigments (mg/g fresh wt.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Flower</td>
<td>Leaf</td>
<td>Stem</td>
</tr>
<tr>
<td>IGFRI</td>
<td>2%</td>
<td>14.02</td>
<td>56.5</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>4%</td>
<td>12.23</td>
<td>42.4</td>
<td>3.6</td>
</tr>
<tr>
<td>S-450</td>
<td>6%</td>
<td>11.08</td>
<td>36.8</td>
<td>3.2</td>
</tr>
<tr>
<td>Control</td>
<td>2%</td>
<td>8.00</td>
<td>33.4</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td>4%</td>
<td>7.87</td>
<td>38.2</td>
<td>2.5</td>
</tr>
<tr>
<td>NP-3</td>
<td>6%</td>
<td>10.70</td>
<td>42.3</td>
<td>4.4</td>
</tr>
<tr>
<td>Control</td>
<td>2%</td>
<td>6.50</td>
<td>38.0</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td>4%</td>
<td>6.20</td>
<td>29.5</td>
<td>3.6</td>
</tr>
<tr>
<td>RG</td>
<td>6%</td>
<td>7.93</td>
<td>36.2</td>
<td>6.0</td>
</tr>
<tr>
<td>Control</td>
<td>2%</td>
<td>4.30</td>
<td>28.6</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td>4%</td>
<td>3.60</td>
<td>25.0</td>
<td>7.6</td>
</tr>
<tr>
<td>Control</td>
<td>2.80</td>
<td>22.0</td>
<td>13.8</td>
<td>13.8</td>
</tr>
</tbody>
</table>
on cowpea cultivars. The treatment of KNO₃ (2%) was effective in increasing the seed yield. Components of IGFRI-450 and Russian grain was affected highly whereas in NP₃, 4% KNO₃ developed physiological potential in relation to seed components (Table-22).

A field experiment was laid out to evaluate the effects of KNO₃ on soluble sugar, photosynthetic pigments, MR activity and seed yield components of clusterbean. Two foliar sprays of KNO₃ comprised of 0, 1, 2, 3, 4 and 5 kg/ha were sprayed at 60 and 75 days of sowing. Foliar application of KNO₃ (1 kg/ha) increased pod formation (92/plant), seeds (610/plant) and 1000 seed weight. It also enhanced the level of photosynthetic pigments in comparison to control and other KNO₃ treatments. On the contrary, less amount of water-soluble sugar and NR activity were recorded in vegetative parts, but high sugar content in flower (28.2%) indicating efficient translocation of sugar from vegetative to reproductive organs. Seeds of clusterbean soaked with 2 to 8% KNO₃ for 24 hrs sown in pots. There was gradual increase in water soluble sugar in flower, collar and stem up to 6% beyond which slight decrease was noticed. This concentration also improved the level of photosynthetic pigments. This resulted in maximum pod (45.8 pod/plant, and 14.1 gm pod weight/plant) and gave 6.56 gm seed/plant while the control produced 20.5 pods and 3.68 g seeds/plant.

A field trial was laid out in randomized block design with 3 replications to find the efficacy of various fertilizers on seed yield of berseem. Fertilizer treatments comprising of KNO₃, UPJAO and DAP @ 50, 100 and 150 kg/ha were applied at the time of sowing having one set of control. Data on seed yield components and water soluble sugar were recorded. In general, the basal application of DAP (150 kg/ha) increased the seed yield, water soluble sugar and carotene content in comparison to control plots. The average effect of fertilizer on seed yield was recorded in order of Diammonium phosphate (6.3 q/ha), KNO₃ (6.05 q/ha) and UPJAO (5.7 q/ha) in comparison to control (5.02 q/ha).

A pot experiment was also conducted to evaluate the effects of seed soaking with boron and KNO₃ on dry matter accumulation, photosynthetic pigments, water soluble sugar and seed yield of oat. Pre-sowing seed treatment with different concentration of KNO₃ (0, 2, 4 and 6%) and boron (0, 1, 2, 3 and 4%) in the form of sodium tetraborate. 2% KNO₃ interacted with 3% boron gave highest seed yield (5.80 g/plant) of oat over control (3.2 g/plant) because of its significance influence on synthesis of sugar in seedling (13.8%) and utilization of mobilised sugar (16.5%) in developing fertile tiller (4.8) and grain number (267) per plant.

1-5 Physiological basis of variations in growth and yield in forages

(O. P. S. Verma)

Five oats species viz., *Avena pratensis*, *Avena byzantina*, *Avena strigosa* and *Avena sativa* were sown in field to study variations in photosynthetic efficiency as influenced by
<table>
<thead>
<tr>
<th>Species</th>
<th>NAR (mg dm⁻² day⁻¹)</th>
<th>RGR (mg g⁻¹ day⁻¹)</th>
<th>SLW (mg dm⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early sowing</td>
<td>Normal sowing</td>
<td></td>
</tr>
<tr>
<td><em>Avena pratensis</em> L.</td>
<td>35.6</td>
<td>41.6</td>
<td>46.0</td>
</tr>
<tr>
<td><em>Avena abyssinica</em> L.</td>
<td>49.6</td>
<td>50.6</td>
<td>46.0</td>
</tr>
<tr>
<td><em>Avena strigosa</em> L.</td>
<td>69.0</td>
<td>50.0</td>
<td>73.0</td>
</tr>
<tr>
<td><em>Avena byzantina</em> L.</td>
<td>52.6</td>
<td>41.6</td>
<td>36.0</td>
</tr>
<tr>
<td><em>Avena sativa</em> L.</td>
<td>54.3</td>
<td>59.6</td>
<td>43.0</td>
</tr>
</tbody>
</table>
normal and delayed sowing. Data on leaf area, leaf and plant dry weight were collected at 20 days interval and computed the data for NAR, RGR, LAR, SLW, SLA and GR. The NAR varied among species from 46–72, 25–77 and 14–58 mg.dm$^{-2}$ leaf area day$^{-1}$ at 30–50, 50–70 and 70–90 days after sowing respectively in crop sown on 15.10.86, whereas it varied from 53–66, 70–73 and 22–42 mg.dm$^{-2}$ leaf area day$^{-1}$ at 30–50, 50–70 and 70–90 days after sowing, respectively in crop sown on 14.11.86. Variations in RGR were recorded from 80.4–86.6, 28.8.77 and 15–58.7 mg.g$^{-1}$ day$^{-1}$ at 30–50, 50–70 and 70–90 days in crop sown on 15–10–86 and it varied from 89–123, 41–83 and 23–52 mg.g$^{-1}$ day$^{-1}$ at 30–50, 50–70 and 70–90 days in crop sown on 14.10.86. Reduction in LAR and SLW were recorded with the advancement of growth in each species under both dates of sowing. Higher values of mean NAR, RGR, SLW and GR were recorded in *Avena strigosa* in the crop sown on 15.10.86 whereas *Avena sativa* gave maximum NAR value in the crop sown on 14.11.86 (Table–23).
DIVISION OF PLANT PROTECTION

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

1.1 Plant diseases of leguminous forage and their management

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

Survey

Incidences of bacterial blight of guar, lucerne rust, powery mildew of senji were cent per cent. Important additions to CR farm diseases were leaf spots of Crotolaria sp; Desmodium spp; Bauhinia spp; Indigofera spp, Phaseolus spp; root rots of stylo, siratro and stem rot of subabul.

Germplasm evaluation for resistance

The following collections were screened under field conditions for resistance to important diseases.

Field bean: Collectoins (170) against virus, anthracnose, Cercospora leaf spot and bacterial blight and collections 2214-II, 37-I-2, 35-II-2, 1949-I, 33-II, 26-I-2, 21-1, 846-II-2, 846-III, 846-IV and IL-125 were resistant.

Cowpea: Collections (260) against cowpea mosaic and anthracnose. Out of these 115 showed resistance to anthracnose and 39 to cowpea mosaic virus and 26 collections were resistant to both.

Guar: Collections (318) against bacterial blight and Alternaria leaf spot. Cultivar 912-3 was resistant to both. Cultivars viz, 2395-2, HG-75, 2402-1, 23-1, 24-1 and guar 197-1 were moderately susceptible.

Moth: Collections (10) against Bean Yellow Mosaic (BYMV). The cultivars IL 11-84 was highly resistant, cultivars IL-51 and IL-1202-3 were tolerant.
Assessment of losses

Effect of *Uromyces striatus* on yield and quality of lucerne: Infected lucerne leaves having 0–4 rust infection levels were analysed. The total chlorophyll content was reduced (4.84-30%) with the increase in infection level. The dry matter content and minerals Cu, Fe and Zn were increased with the increase in infection levels.

Disease management

Efficacy of fungicidal seed treatment in controlling dry root rot (*Macrophomina phaseolina*) of cowpea: Benomyl, Bavistin, Blitox, Captan, Cerasan dry, Difo'atn M-45, Dithane Z-78 and thiram in-vitro by poisoned food technique at concentrations- 100 ppm, 200 ppm, 400, 600, 800 and 1000 ppm. Thiram and cerasan dry were most effective inhibiting the growth of test pathogen at 400 ppm level. Benomyl, Bavistin, Captan, Cerasan dry and Thiram were (%) tested @ 0.25% for their efficacy against dry root rot in pot and field. The treatment with Thiram reduced the pre and post emergence rooting of seeds by 23.4% in pots and 31.37% in field. Seedling symptoms were also reduced by 25 and 18.2% in pots and field respectively.

Chemical control of guar leaf spot (*Alternaria* spp.) and bacterial blight (*Xanthomonos* spp.): Guar seeds were treated with hotwater (50°C for 10 mnts.), Thiram (0.25%), Agrimycin (0.25%), followed by sprayings with Bavistin (0.01%). It was observed that hot water seed treatment +2 sprayings was most effective. The treatment maintained 5 per cent disease incidence as compared to 40 per cent in the control. Seed yield was 19% more over the control.

Basic studies

Growth and Sclerotia formation of *Sclerotium rolfsii*: Six different media viz., Potato Dextrose Agar, Martins medium, Richards Agar, Crepeck Agar medium, Bean leaf extract Agar medium and corn meal Agar medium were tested. Best growth and sclerotia formation occurred on bean leaf extract agar medium, however, growth was good in martins medium, and PDA medium but poor sclerotia formation.

Influenced of different soil amendments on soil microflora: The results indicated that chopped parthenium leaves added soil was enriched with Fungi, bacteria and actinomycetes, however, addition of carbofuran and sawdust + urea decreased the microbial population.
1.2 Plant diseases of non-leguminous crops and their management

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

Survey

Safflower and mustard were observed with heavy infection of rust and leaf spots respectively. Dichanthium sp. and Schima sp. were badly damaged by rust and Pyrenophora leaf spot. In sorghum, heavy infection of grey leaf spot (*Cercospora sorghi*), leaf blight (*Helminthosporium turcicum*), anthracnose (*Colletotrichum graminicola*) and grain smut (*Sphacelotheca sorghi*) were predominant.

Germplasm evaluation for resistance

Sorghum germplasm collections (105) screened for resistance to anthracnose, leaf blight and grey leaf spot diseases. Seventeen collections were disease free, 27 collections were resistant at seedling stage. In young plant stage, *Sorghum vireatum*, *S. alnum*, *S. heleneense* and 212605 were resistant.

Disease management

The crown rust of oats spread fast on monocrop and reduced the grain formation percentage. The rust spread was considerably delayed if grown in mixture legumes. Relative yield of plants grown were more than plants in mono-crop. Sorghum genotypes (11) remained free from foliar diseases upto June when sown in March.

Chemical control of diseases of M.P, Chari: M.P. Chari was given seed treatments with Hot water, Agrimycin and Thiram followed by one or two sprays of Bavistin on the crop. Seed treatment with Thiram followed by 2 spraying of Bavistin @ of 0.1 per cent significantly reduced the diseases incidence from 4.5 to 1.5 and increased the green fodder yield and seed yield.

In vitro evaluation of fungicides against *Helminthosporium turcicum* and *Colletotrichum graminicola*: Eight systemic and non systemic fungicides were evaluated through poisoned food technique. The colony diameter of the pathogens were measured after 7 days of incubation. Thiram @ 0.25 per cent was found most effective against both the pathogens. The colony diameters of the test fungi was 0 mm while it was 69.5 and 80.7 respectively on PDA (Table 24 & 25).

Disease of mustard: Mustard raised in plots were applied with either Dithane M-45 @ 0.25% (1-3 sprays) or Bavistin @ 0.1% (1-3 sprays) in replicated manner. It was observed...
Table-24 : Effect of different fungicides on growth of *Helminthosporium turcicum* and *Colletotrichum graminicola*.

<table>
<thead>
<tr>
<th>Fungicides</th>
<th>Dose</th>
<th>Colony diameter (mm.)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><em>H. turcicum</em></td>
<td><em>C. graminicola</em></td>
</tr>
<tr>
<td>Benomyl</td>
<td>0.01</td>
<td>8.5</td>
<td>7.5</td>
</tr>
<tr>
<td>Bavistin</td>
<td>0.01</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Agrimycin</td>
<td>0.25</td>
<td>18.25</td>
<td>21.25</td>
</tr>
<tr>
<td>Captan</td>
<td>0.25</td>
<td>8.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Captafol</td>
<td>0.25</td>
<td>24.25</td>
<td>21.0</td>
</tr>
<tr>
<td>Thiram</td>
<td>0.25</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Dithane 2-78</td>
<td>0.25</td>
<td>55.25</td>
<td>65.0</td>
</tr>
<tr>
<td>Dithane M-45</td>
<td>0.25</td>
<td>23.5</td>
<td>28.0</td>
</tr>
<tr>
<td>Control</td>
<td>—</td>
<td>69.5</td>
<td>80.75</td>
</tr>
</tbody>
</table>

Table-25 : Effect of fungicidal seed treatment on seed germination and recovery of *Helminthosporium turcicum* and *Colletotrichum graminicola*

<table>
<thead>
<tr>
<th>Fungicides</th>
<th>Dose</th>
<th>Recovery percent</th>
<th>Seed germination (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><em>H. turcicum</em></td>
<td><em>C. graminicola</em></td>
</tr>
<tr>
<td>Benomyl</td>
<td>0.25</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bavistin</td>
<td>0.25</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Agrimycin</td>
<td>0.25</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Captafol</td>
<td>0.25</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Captan</td>
<td>0.25</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Thiram</td>
<td>0.25</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Dithane M-45</td>
<td>0.25</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Control</td>
<td>—</td>
<td>16</td>
<td>24</td>
</tr>
</tbody>
</table>
that Dithane M-45 with 3 sprays at 15 days interval proved superior over Bavistin. The fungicide Dithane M-45 increased appreciably the seed yield of mustard.

Basic studies

*Helminthosporium turcicum* & *Colletotrichum graminicola* from M. P. Chari were isolated and maintained on artificial media. On re-inoculation, the fungus produced symptoms at 4 leaf stage. Growth and sporulation of *H. turcicum* was studied in 7 media, viz. Potato Dextrose agar, Martins medium, Richards agar, Czepecks agar, Bean leaf extract agar, Cornmeal extract agar and sorghum leaf extract agar. Out of these, sorghum leaf extract agar was found best for she growth and sporulation of the test pathogen, however growth was better on PDA but the sporulation was less than sorghum leaf extract agar medium.

1.3 Insects associated with leguminous forage and their management

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

Major insects incidences

In lucerne aphids (*Theroaphis mact lata* and *Acyrthosiphon pisum*) are active from November to April; Lucerne weevil (*Hypera postica*) is active from January to March. Seed chalcid (*Bruchophagous roddi*) damage lucerne pods from mid April to June. In cowpea leaf hopper (*Empoasca* spp.) remains active from July to November; semi loopers (*Plusia nigrisigna* and *P. orichalceay*) are active from July to October, but damages reaches peak in September. flea beetle (*Pagria signata*) was prevalent during July to November.

Evaluation for tolerance to insects pests

**Lucerne** : Three plants of IL-40, -49 and 1418 showed high degree of tolerance to aphids and lucerne weevil.

**Field bean** : Leaf hoppers were most prevalent in all the 150 lines. Lines 22, 26-I-2, 126, 1987-8, 1987-10, 27-II-2, 33-II, 1642-III-1, 36-I-2, 21-I, 18-II showed high tolerance.

**Cowpea** : Out of 250 lines evaluated, 13 lines viz. IL-132, 160A, 178-A, 210, 417, 461B, 499 1062B, 1082, 1235, 3169, 3186 and Hy. 8 FCC-19 were tolerant to flea beetle and 105 moderately tolerant.

**Chemical control**

**Lucerne** : Six chemical were sprayed at 35 days, 55 days and 70 days crop. All the
insecticides gave significant control of aphid and lucerne weevil. The performance of insecticides was Cypermethrin (0.01%) > Dimecron (0.04%) > Thiodan (0.03%) > Sumithion (0.04%) > Nuvan (0.04%) > Malathion (0.02%). Highest fodder yield (130 q/ha, 185 q/ha) was obtained in Cypermethrin.

**Cowpea**: Five insecticides viz. Thimet (2.5 kg/ha), Temik (0.5 kg/ha), Cypermethrin (0.1%) Thiodan (0.05%) and Malathion (0.05%) were tested for their efficacy against insect pests. Thimet and Temik were applied as granules at time of sowing and after 30 days. Other insecticides were applied as sprays at 30 days and 60 days in crop. The granular insecticides controlled leaf hoppers effectively. Cypermethrin with 2 sprays applications gave maximum control of insect pest and fodder yield (Table-26).

In another experiment soil application of neem cake (20 q/ha), Carbofuran furrow application (20 kg/ha), Carbofuran seed treatment (2% w/w), soil application of Neem cake + Carbofuran seed treatment (10q/ha +1% w/w), and untreated. Least infestation of leaf hoppers was in carbofuran furrow treated plants (8.25%). Flea beetle damage was least in Neem cake + Carbofuran treated plants. Green fodder yield was maximum in Neem cake treated pots (313 q/ha).

**Insect transmission of CPMV.**

*A. gossypii* and *M. persicae* could transmit the virus. *A. gossypii* transmission percentage was 50 whereas *M. persicae* could transmit only 20%. The virus persisted in insect upto 2 hrs.

1.4 **Insects associated with non-leguminous forages and their management**

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

**Evaluation of germ plasm for reaction to insect pests**

*Sorghum*: 101 lines were evaluated for reaction to shootfly *Atherigona soccata*. Out of these, 95 lines belonging to *Sorghum bicolor* were grouped into 8 classes. (Table-27). Among sorghum species, *S. lanceolatum* had the highest % DM (38.83) followed by *S. roxburghii* (26.78), *S. acthiopticum* (19.40), *S. virgatum* (13.53), *S. helene* (5.00) and *S. alnum* (5.37).

**Barley**: 57 lines of previously identified as tolerant were again tested for aphid infestation. Tolerant lines were K-50, K-67, K-80, K-85, K-137, Icarda-153, BP/RC-41 and IC-36773, but lines K-713, K-110, Icarda-167 and K-92 were heavily damaged, this year. These lines had possibly escaped infestation previous years.
### Table-26: Chemical control of insect-pests of cowpea

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>No. of Applications</th>
<th>% leaf Hopper infested plants</th>
<th>Flea beetle damage perforations/leaf</th>
<th>Semi looper damage</th>
<th>Green fodder yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>NP-3</td>
<td>Do Fasali</td>
<td>NP-3</td>
<td>Do Fasali</td>
</tr>
<tr>
<td>Temik</td>
<td>1</td>
<td>7.50</td>
<td>10.50</td>
<td>3.35</td>
<td>5.00</td>
</tr>
<tr>
<td>Thimet</td>
<td>1</td>
<td>13.00</td>
<td>8.00</td>
<td>3.47</td>
<td>4.77</td>
</tr>
<tr>
<td>Cypermethrin</td>
<td>1</td>
<td>25.50</td>
<td>23.50</td>
<td>2.40</td>
<td>2.12</td>
</tr>
<tr>
<td>Malathion</td>
<td>1</td>
<td>30.00</td>
<td>24.00</td>
<td>2.62</td>
<td>3.02</td>
</tr>
<tr>
<td>Thiodan</td>
<td>1</td>
<td>21.50</td>
<td>5.50</td>
<td>1.67</td>
<td>2.10</td>
</tr>
<tr>
<td>Temik</td>
<td>2</td>
<td>11.00</td>
<td>10.50</td>
<td>1.50</td>
<td>2.37</td>
</tr>
<tr>
<td>Thimet</td>
<td>2</td>
<td>14.00</td>
<td>10.00</td>
<td>1.55</td>
<td>1.12</td>
</tr>
<tr>
<td>Cypermethrin</td>
<td>2</td>
<td>20.50</td>
<td>17.00</td>
<td>1.90</td>
<td>1.10</td>
</tr>
<tr>
<td>Malathion</td>
<td>2</td>
<td>23.00</td>
<td>29.50</td>
<td>1.90</td>
<td>1.75</td>
</tr>
<tr>
<td>Thiodan</td>
<td>2</td>
<td>30.50</td>
<td>21.00</td>
<td>2.00</td>
<td>3.10</td>
</tr>
<tr>
<td>Control</td>
<td>0</td>
<td>45.50</td>
<td>58.50</td>
<td>5.17</td>
<td>10.05</td>
</tr>
</tbody>
</table>
### Table 27: Reaction of sorghum germplasm to shootfly (*Atherigona soccata*)

<table>
<thead>
<tr>
<th>Class</th>
<th>Range of % DH</th>
<th>Name of lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0.0 – 5.0</td>
<td>Nil</td>
</tr>
<tr>
<td>2.</td>
<td>5.1 – 10.0</td>
<td>IS-2219-A</td>
</tr>
<tr>
<td>3.</td>
<td>10.1 – 15.0</td>
<td>IS-212597, 212601, -02-04, 2219-B, 2277-B</td>
</tr>
<tr>
<td>4.</td>
<td>15.1 – 20.0</td>
<td>IS-212528, -89-94-28, 212603, -50-06, -07-13</td>
</tr>
<tr>
<td>5.</td>
<td>20.1 – 25.0</td>
<td>IS-212506, -67-79-99, 212623, -25, 2077-A</td>
</tr>
<tr>
<td>6.</td>
<td>25.1 – 30.0</td>
<td>IS-212548, -59, -63, -72, -73, -78, -83, -91, 212609, -12, -13, -28, 295-B</td>
</tr>
<tr>
<td>8.</td>
<td>50.1 &amp; Above</td>
<td>IS-212552, -54, -64, -68, -69, -74, -76, -80, -86, -212624, -26, -28, -32</td>
</tr>
</tbody>
</table>

*Carthamus*: Out of 87 lines, Nos. 76-34, 76-24, 76-252, 76-83-1 were least infested by aphid *Uroleucon comosita* and Nos. 76-21, 83-26 and 76-19 showed the minimum (upto 15%) safflower fly damage.

### Chemical control of forage insect pests

**Mustard**: The efficacy of five insecticides viz. dimethoate, endosulfan, monocrotophos and fenvalerate for control of aphid was tested in a randomized block design with four replications. The pre-treatment aphid population varied from 25.8 to 45.3 aphid/shoot. Er.dosulfan gives significantly low aphid mortality (Table-28).

**Sorghum**: Soil application of Carbofuran 3 G @ 3 g/m was found most effective against shootfly in comparision to phorate 10G, 1.5 g/m, 3 g/m and Temik 10G, 1.5 g/m, 3 g/m. Economy in insecticide use was assessed. Mixture of 5% Carbofuran w/w treated
Table-28: Efficacy of some insecticides against *Lipaphis erysmae* on mustard

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% aphid mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 days</td>
</tr>
<tr>
<td>Dimethoate (0.25%)</td>
<td>95.6</td>
</tr>
<tr>
<td>Endosulphan (.025%)</td>
<td>65.8</td>
</tr>
<tr>
<td>Monocrotophos (.025%)</td>
<td>96.8</td>
</tr>
<tr>
<td>O,O-demeton methyl (.025%)</td>
<td>98.8</td>
</tr>
<tr>
<td>Fenvalerate (01%)</td>
<td>96.7</td>
</tr>
</tbody>
</table>

and untreated seeds in proportions viz. 80:20, 60:40, 50:50 and 40:60. Seed mixture of 60:40 effectively reduced the pest population (12.5% dead hearts).

**Physiological studies on pest insects**

*Bagrada hilaris*: Female adults of some age were fed on 0.02% Endosulfan sprayed plant material for 12, 24 and 36 hrs and *in situ* stained preparations were studied to see the impact of insecticide on the neuroendocrine system. The NSC of treated insects showed increase in cell nuclear diameter ratio, lesser quantity of NS colloide in the cells but clogging of this material in the axons and aorata as compared to the normal insects. There was however no significant difference in the cell of the corpora cardiaca and corpus allatum (Table-29).

Table-29: Effect of insecticide treatment on the Neurosecretory system of *B. hilaris*

<table>
<thead>
<tr>
<th>Component</th>
<th>Treated</th>
<th>Untreated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mediancells ‘A’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Cell diam</td>
<td>28</td>
<td>25</td>
</tr>
<tr>
<td>(ii) Nuclear diam</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>N. S. Colloid</td>
<td>Depleted</td>
<td>loaded</td>
</tr>
<tr>
<td>(i) Cells</td>
<td>Fully loaded</td>
<td>partially loaded</td>
</tr>
<tr>
<td>(ii) Axons</td>
<td>Fully loaded</td>
<td>partially loaded</td>
</tr>
<tr>
<td>(iii) Aorta</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Studies on *Solenopsis germinata* whose repellancy to the aqueous extracts of some grass seeds (dispersal units) which contain, Phenolic acids, Hydroxycinnamic acid and flavinoids, *Cenchrus ciliaris*, *C. setgerus*, *Dichanthium annulatum*, *Bothriochloa intermedia*, *B. pertusa*, *Sehima nervosum* and *Chrysopogon fulus* were tested.

1.5 Plant parasitic nematodes associated with herbaceous forage legumes and their management

(N. Hasan and R. K. Jain)

Residual effect of organic amendments on nematodes and forage yield

Berseem and lucerne as monocultures as well as in mixtures were grown in plots already treated in kharif 1986 with neem cake (@ 20 q/ha), carbofuran (@ 2 kg a.i./ha.), parthenium chopped leaves (@ 50 q/h), sawdust (@ 30 q/h) alongwith untreated control. The treatments reduced total parasitic nematode and increased dry matter yield of the crops. Sawdust followed by neem cake proved most effective. Maximum percentage increase in dry matter yield of lucerne (81.50), oat (21.40), berseem+oat (38.36), lucerne+oat (36.57) over the control was observed in sawdust, while in berseem it was highest (64.57) per cent in neem cake. Maximum reduction in total parasitic nematode in all crops was also recorded in sawdust (26–38.50) followed by neem cake (25–34.50) per cent over control (Table-30).

Table-30. Residual effect of organic amendments on per cent reduction in total phytoparasitic nematodes over the control

<table>
<thead>
<tr>
<th>Crops (Rabi 1986-87)</th>
<th>Neem cake</th>
<th>Carbofuran</th>
<th>Parthenium</th>
<th>Saw dust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berseem</td>
<td>34.50</td>
<td>0</td>
<td>30.00</td>
<td>38.50</td>
</tr>
<tr>
<td>Lucerne</td>
<td>25.25</td>
<td>0</td>
<td>24.63</td>
<td>28.62</td>
</tr>
<tr>
<td>Oat</td>
<td>40.00</td>
<td>5.60</td>
<td>26.74</td>
<td>40.85</td>
</tr>
<tr>
<td>Berseem+Oat</td>
<td>30.20</td>
<td>7.25</td>
<td>25.00</td>
<td>34.66</td>
</tr>
<tr>
<td>Lucerne+Oat</td>
<td>25.00</td>
<td>3.66</td>
<td>20.00</td>
<td>26.00</td>
</tr>
</tbody>
</table>
Integrated management of root-knot nematode *M. incognita* infecting cowpea

In a field experiment on the integrated nematode management of cowpea all the four treatments significantly reduced the nematode infection and also increased the fresh and dry matter yield (Fig. 4). Highest increase in green (37.59%) and dry matter (70.56%) yield was recorded when deep ploughing was combined with neem cake (at 20 q/h) treatment in furrows. However, highest reduction in root-knot index (73.33%) and final nematode population (88.9%) was observed in carbofuran (at 2 kg a.i./h.) treatment.

Evaluation for resistance

Cowpea variety IL-515 was found to be tolerant whereas IL-143, IL-978, IL-985 and Hy-3-P-3 were moderately susceptible to *M. incognita*. In addition, the known resistant variety C-152 remained resistant in Jhansi condition also. Among field bean, lines IL-451 showed resistance while IL 28, 216, 836 and 130 were moderately resistant to *R. reniformis*. The cowpea germplasm viz. IL 1155/A, 899, 1116, 3166, 390, 8705, Hy 8 P60-9/A, Hy5 P53-2 and Hy 5 P5-3 proved to be resistant against *M. incognita* in field conditions.

Interaction between root-knot nematode and *Fusarium* spp. on cowpea wilt

The results revealed that there was comparatively greater reduction in plant growth when both the organisms present together, being highest (75.0%) in which the nematodes were inoculated 15 days prior to the fungus. Nematode reproduction was apparently reduced in the presence of fungus but were not significant.

1.6 Plant parasitic nematodes associated with herbaceous non-leguminous forage crops and their management

(R. K. Jain and N. Hasan)

Screening of sorghum species/lines against cyst (*Heterodera sorghii*) and spiral (*Helicotylenchus dihystera*) nematodes

Fifty lines of *Sorghum bicolor* and species, *S. roxburghii*, *S. verigatum*, *S. aethiopicum*, *S. lanceolatum*, *S. almum*, *S. helepense* were screened against cyst and spiral nematodes in pots and field. All the species were susceptible to both the nematodes in pot experiments. However, the degree of susceptibility varied, in which *S. helepense* proved least susceptible to both the nematodes. In the field screening of 50 lines, *H. dihystera* was most predominant (100%) with high population density (250-400/250 g soil). Smallest population density was recorded from lines 212546, 212557, 212563, 212573, 212580, 212602, 212612, 2219-A and 2077-B suggesting their resistant.
Fig. 4—Management of root knot nematode *M. incognita* in cowpea
Vesicular-arbuscular endomycorrhizal (VAM) fungi associated with sorghum and bajra, their evaluation against key nematode species infecting these crops

Root samples were collected from sorghum and bajra fields to determine the incidence and degree of infection caused by VAM fungi and also testing them in pots as well as in microplots infested with spiral, stunt, lesion and root-knot nematodes.

Out of 5 species belonging to 3 genera of VAM fungi, *Glomus mosseae* was most predominant (100%) with 70-85% root colonization; 84-178 spores/100 g soil. In pots and the microplot experiments, *G. mosseae* was found most efficient in improving the plant growth of *Sorghum bicolor* and bajra var. 81-B (35-67%) without affecting the ectoparasitic nematodes. However, low incidence of root-knot infecting bajra was observed.

1.7 Nematodes associated with shrubs and trees of forage value and their management

(M. I. Azmi)

In continuation of earlier studies under this project following studies were conducted.

1. Approximately 50 plants and soil samples were collected, nematodes were isolated. Surveys indicated that the nematodes were below their injury levels.

2. Out of eight different lines and species of Subabul (9-10 yrs. old), 4 showed minimum infestation levels of *Meloidogyne* spp. (i.e. 704 to 3000 nematodes per g root) and least susceptible (3-6 galls per 10 cm. root). The species were *Leucaena diversifolia*, *L. collinsi*, *L. leucocephala*, CPJ-23412 and *L. pulcerulenta*.

3. Highly infested field with *Tylenchorhynchus* spp, were applied with Carbofuran to study its effect on the nematode population in siris nursery. Within 100 days 75 mg/m² at carbofuran reduces 44% nematode population and increases 44% weight of seedlings over control. A dose of 100 mg/m² decreases 77% nematode population and increases 53% weight of seedlings. Treatments were given along the seeds in the furrows.

4. The effect of tillage and solarization on the nematode populations was studied in a moderately infested field. Out of four practices a 20 cm. deep ploughing followed by leveling after 6 days reduces 58% nematode populations within 15 days whereas after 3 months only 1.7% decrease of nematodes were observed. It has been established that initial populations of plant-parasitic nematodes at the time of sowing affect the yield. This method is useful to reduce nematode number before sowing.
5. In pots, studied rate of multiplication of stunt nematode *Tylenchorhynchus* spp. on five species of siris, (*Albizia* spp.). It was found that *A. moluccana*, *A. richardiana* are less suitable hosts of *Tylenchorhynchus indicus*.

6. In pot, studied the effect of deoiled cakes of same tree seeds. Neem cake was most effective in reducing the plant parasitic nematodes (ch. root-knot nematodes) attacking su-babool seedlings other cakes i.e. Caster and *Mahua* were least effective. A dose of 3% w/w. mixed in soil reduces 40 to 66% nematode populations and significant increase in seedlings vigour and weight were recorded.
1.1 Development of Densifying Machine

(Jai Singh)

A reciprocating ram type machine has been developed to produce high density bales of wheat bhusa, chaffed stovers, rice straw, grasses and tree leaves for economic storage, handling and transport. Wheat bhusa is baled at 15-36% moisture content (wb) by adding 10-15% molasses. The baled density of these feeding stuffs ranged between 350-400 kg/m$^3$ thus reducing the stack volume of grasses, tree leaves and paddy straw from 15.4 m$^3$/ton to 2.8 m$^3$/ton and that of manually pressed wheat bhusa and chaffed stovers from 5.9 m$^3$/ton to 2.6 m$^3$/ton. The output capacity of the machine is about 2.0 t/hr and baling costs around Rs 80.00 per ton. Weight of the bale is adjustable from 15-25 kg.

Constructional details of the machine and operation

The machine consists of a frame, a gear drive crank mechanism, receiving chamber, compressing chamber and split extension chamber. All components of the machine are mounted on the frame. The drive consists of a fly wheel and pairs of cylindrical gear wheels. The compressing chamber comprises a feeding hopper and a closed die of rectangular cross section. The extension chamber is a mechanism in the form of a half closed rectangular box which is attached to the outlet of the compressing chamber and provides the counter pressure required in densification and conveying the bales. The requisite working pressure of the press and hence the density of the packages produced are adjusted with the aid of a set of spring loaded belts fixed at the end of this chamber. The machine is driven from an electric motor of 32 KW through flat belt and pulley system.

The material enters the open die from the feeding chute during the return stroke of
Fig. 5: Effect of piston travel on applied pressure at a moisture content of 15% in the process of wafering.
the ram. On the forward stroke of the ram, the material is carried into the compression chamber where it is pressed. The process is a continuous one. The ram describes 32 strokes per minute. The pressed material is tied with one of three wires of 14 gauge.

1.2 Testine of IGFRI seed pelletizer to produce feed pellets for goats

(Jai Singh)

IGFRI seed pelletizers were tested for producing feed pellets from poultry droppings, cattle dung and other fine textured cellulosic waste materials in combination with cake, wheat bran, mineral mixture and salt at Central Institute for Research on Goats, Makhdoom (CIRG). This is considered as a potential alternate feed resource for goats. The mixture contained 60 kg poultry droppings or cattle dung, 17.5 kg wheat bran and 5 kg mineral mixture and salt. All weights are in kg/100 kg DM. A paste of semisolid consistency is prepared by adding 20-35% water in the mixture before feeding into the machine for pelleting. Both the power operated and the hand tool worked satisfactorily.

Constructional details and operation

The power operated machine consists of an auger, auger housing, shaft to drive the auger, multi-hole pressure plate, feeding chute and flat belt power transmission system. The auger carries the material and presses it against the pressure plate where the material comes out in the form of cylindrical feed bars. These bars break into small pieces of 25-40 mm length as they come out of the machine and are called pellets. These pellets are air dried, bagged and stored for feeding.

The hand feed pelletizer has been developed by modifying the commercially available seewai making machine, popularly used as domestic tool in the kitchen. The conventional sieves in this machine have been replaced by a 12 mm thick plate having tapered holes of 8-12 mm diameter.

1.3 Development and testing of harbage wafering machine

(Jai Singh and P. S. Chattopadhyay)

The flywheal of the machine was redesigned and modified to conserve mechanical
energy during the idle stroke and to reduce the amplitude of vibration. The moment of inertia increased from 6.2 to 10.1 kg/m².

The feeding mechanism was improved by providing a mechanical agitator in the feeding hopper. The improved prototype was tested for functional performance on compression.

Herbage mixtures and their behaviour to compression

Three mixtures of *Sesbania* leaves + grass, subabool leaves + grass and Stylo + grass in the proportions of 1:1, 1:2 and 1:3 were prepared and wafered at pressure ranging from 15 to 40 MPa. In all cases the wafers formed at 15–16 MPa pressure could not withstand handling as they disintegrated. The other wafers, prepared from the mixture of legumes + grass up to 1:2 proportions, were firm and had retained good shape. But the wafers prepared from the legume + grass mixture in 1:3 proportion were very loose and deshaped in handling. The relationship between deformation of hay and the specific pressure was determined experimentally. It was noted that at the first stage deformation, the pressure requirement is less and then the requirement increases exponentially.

1.4 Feasibility testing and performance evaluation of improved farm implements on farmers fields

(Jai Singh and P. S. Chattopadhyay)

IGFRI Rotary Disc Mower

The cutting unit of the machine was improved by increasing the moment of inertia of the discs from to 0.63 kg m⁻². It was achieved by increasing the diameter and weight of the discs. The modified version gave clean and uniform cutting and windrowing. Field capacity was observed 0.36 ha/hr. and saving in Rs. 95/- ha over the traditional sickle harvesting.

Package of implements for Grassland and Silvipasture production system

The package included tractor driven Post Hole Digger to make pits for tree plantation, Pod Plucer to harvest tree seed pods and seed pelletizing machine.
Field capacity of the Post Hole Digger in gravelly red sandy loam soil was 0.056 ha/hr at 3m x 3m pit spacing. Its use resulted in saving of Rs. 300/ha in labour in digging pits of 45 cm diameter and 100 cm depth. Significant increase in height (79.5%) and girth (42.4%) was observed in plants planted in mechanically dug pits over manually dug conventional pit size of 45 cm diameter and 45 cm depth over a growth span of 150 days.

The IGFRI seed pelletizer was evaluated for Stylo (Stylosanthis humilis), Siratro (Macroptelium purpuratum), Subabool (Leucaena leucocephala) and Desi babool (Acacia nilotica). Seed ratio of 10:1, for Subabool and Desibabool, and 100:1 for Stylo and Siratro was found to be optimum. On average each pellet contained 3 seeds. The mechanical injury caused to the seeds was determined through laboratory germination tests of pelleted and non-pelleted seeds which ranged between 2.5 to 12.8 per cent. Minimum injury of 2.2% was noted in Desi babool against a maximum of 12.8% in Stylo. Output capacity of the machine was 118 kg/hr.

The pod plucker gave 16.9% higher output over the local Ghukiya. The matured-immatured pod ratio was 1.01 and 0.43 for pod plucker and Ghukiya, respectively.

Sowing-cum-fertilizer application devices for oil seed crops

IGFRI single-row and two-row seed drills gave satisfactory results in sowing mustard, sesamum, linseed and safflower crops also.

Feasibility testing of a NSP Multicrop Thresher for oil seeds, cereal and fodder crops

The thresher was evaluated for safflower, mustard, wheat and oat crops. The output capacity varied from 48 kg/hr for safflower to 80 kg/hr for wheat. The threshing efficiency varied from 97.1 to 100 per cent and cleaning efficiency from 83 to 94.2 per cent. The threshing losses in terms of broken grain, blown grain and unthreshed grain were within permissible limit.

Feasibility testing of improved sickle for harvesting oil seeds, cereal and fodder crops
The improved sickle increased the work efficiency by 26, 25.4, 2.3 and 7.5 per cent over local sickle in safflower, barley, oat and berseem crops respectively. The man hours required per ha was reduced by 6.97, 15.69, 2.25 and 5.85 per cent for safflower, barley, oat and berseem crops respectively.
1.3 Economics of forage production and forage based animal production systems

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

1. Economics of mixed cropping

The following field experiments were conducted at the Institute. *Setaria sphacelata* and hybrid napier planted at 1 m row spacing were intercropped with 2 rows of cowpea (HFC 42-1). The results are summarised below:

*Setaria* + Cowpea

In this system the green fodder production was 190.82 q/ha from *Setaria* and 99.6 q/ha from cowpea. The cost of cultivation was Rs. 855.59/ha giving net income of Rs. 4390.33/ha. Benefit cost ratio for mixed stand was 4.89.

Hybrid napier + Cowpea

The cost of production of hybrid napier + cowpea for fodder was Rs. 1340.80/ha. Total green fodder production from grass and legume was 112.0 and 54.0 q/ha respectively. The net income was Rs. 1980.60/ha with an input-output ratio of 1:2.48, giving a net profit of Rs. 1.48 per rupee of investment.

Cereal - Legume mixture

Six crop combinations viz; maize + cowpea, teosinte + cowpea, *Pennisetum pedicellatum* + cowpea, sorghum pionear-988 + cowpea, M. P. Chari + cowpea and PC-6 + cowpea were evaluated in terms of fodder production and economic returns. The data
revealed that the sorghum Pioneer-988 + cowpea HFC 42-1 produced maximum green fodder production of 233.34 q/ha. The cost of inputs per hectare was same for different crop combinations because of their matching agronomic requirements.

The gross return was calculated on the basis of prevailing price of green fodder varying from Rs. 16 to 20/q in local market. Sorghum pioneer-988 + cowpea was the best (233.34 q/ha) followed by teosinte + cowpea (216.67 q/ha), PC-6 + cowpea (213.34 q/ha), maize + cowpea (165.00 q/ha), M. P. Chari + cowpea (161.67 q/ha) and Pennisetum pedicellatum + cowpea (158.34 q/ha).

The highest input output ratio of 1:2.38 was observed with PC-6 + cowpea followed by 1:2.37, 1:2.34, 1:1.85, 1:1.82 and 1:1.76 for teosinte + cowpea, Sorghum pioneer + cowpea, maize + cowpea, M. P. Chari + cowpea and Pennisetum pedicellatum + cowpea respectively.

2. Economics of Agroforestry system

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

The field experiment was conducted at farmers demonstration block at IGFRI, Jhansi during kharif 1987. Maize, teosinte, Pennisetum pedicellatum, sorghum Pioneer-988, M. P. Chari and PC-6 were grown along with subabool in agroforestry system.

The gross return was calculated on the basis of prize of green fodder at Rs. 20/q for all cultivated crops and Rs. 10/q for subabool prevailing in the local market. When compared in terms of harvested green fodder, maize was the best (208.34 q/ha) followed by PC-6 (200/q), M. P. Chari and sorghum Pioneer-988 (183.34 q/ha), teosinte (166.67 q/ha) and Pennisetum pedicellatum (150.00 q/ha). The data on cost return analysis revealed that the highest gross output was realised with maize in combination with subabool which in turn resulted in the highest net return Rs. 2544.43/q/ha. The lowest net return (Rs 1411.12 q/ha) was observed in the Pennisetum pedicellatum with subabool. The highest input output ratio of 1:2.35 was worked out with maize + subabool followed by 1:2.32, 1:2.14, 1:2.09, 1:1.93 and 1:1.75 for PC-6 + subabool, M. P. Chari + subabool, sorghum Pioneer-988 + subabool, teosinte + subabool and Pennisetum pedicellatum + subabool respectively.

3 Economics of different pasture grasses

(I. P. S. Yadav and U. S. Mishra)

a Dicranthis n annulatum: The field experiment was conducted during kharif 1987
with ten promising varieties of *Dichanthium* to identify their fodder production potential for achieving higher economic returns/ha.

In the establishment year, gross income was Rs. 1040.19/ha against total cost of Rs. 1531.17 which resulted in loss of Rs. 486.46/ha.

(b) *Cenchrus ciliaris*: The promising varieties were grown and evaluated to identify production potential and higher economic returns. The results showed that the *Cenchrus ciliaris* variety IGFRI-3108 produced maximum green fodder yield of 209.9 q/ha, followed by 679 (208.3 q/ha), 678 (204.60 q/ha), 8-3-1 (195.6 q/ha) and 667 (190.7 q/ha) in two cuts. Variety IGFRI-678 produced maximum dry matter (65.54 q/ha) among all. The cost of production was Rs. 1965.13/ha and gross income Rs. 3543.21/ha with a net income of Rs. 1584.26/ha. The input output ratio was 1:1.81.

(c) *Cenchrus setigerus*: Seven promising strains were studied in order to study their performance for fodder yield, regeneration potential and maximum economic returns. The data on forage production obtained in two cuts for variety 77 recorded 36.59 q/ha dry matter yield. The overall average for all varieties was 131.70 q/ha green, and 35.53 q/ha dry matter. The gross income was worked out to be Rs. 2627.69/ha and the cost of production per hectare Rs 1893.83. The net income Rs. 739.68 was obtained with an input output ratio was 1:1.39.

4. Studies on response and economics of *Pennisetum pedicellatum* varieties to nitrogen levels

(R. A. Singh and S. N. Tripathi)

The experiment was conducted by Agronomy Division to evaluate the performance of three *Pennisetum pedicellatum* varieties IGFRI, S-32-1, S-43-1 and S-866-1 at four levels of nitrogen (30, 60, 90 and 120 kg/ha).

The response to nitrogen was quadratic for all the varieties due to application of nitrogen from 30 to 120 kg/ha. The $R^2$ values showed that the relationship gave a good fit to nitrogen doses explaining 0.9952; 0.9962 and 0.9964 of variations for varieties IGFRI S-32-1, S-43-1 and S-866-1, respectively.

The economic optimum doses of nitrogen for corresponding varieties worked out to be 106, 16, 105.79, and 115.86 kg/ha. The agronomic optimum doses for these varieties were 108.95, 108.44 and 120 kg nitrogen/ha which are higher than the economic optimum.
It is seen that the nitrogen utilization efficiency for variety IGFRI. 43-1 was better than other two varieties. The average green forage yield obtained from *Pennisetum pedicellatum* varieties IGFRI. S-32-1, S-43-1, S-866-1 were 518.75, 540.94 and 570.14 q/ha. With their cost of production Rs. 3638, 3649 and Rs. 3660 respectively. The net profit was Rs. 4132, Rs. 4465 and Rs. 4892/ha at prevailing market price. The input/output ratio was 1:2.14 for variety S-32-1, 1:2.22 for variety 43-1 and 1:2.34 for variety S-866-1. Variety IGFRI S-866-1 gave the maximum green forage yield and net return with higher input output ratio followed by variety IGFRI S-43-1.

**Economics of different forage crop rotations**

(R. A. Singh and S. N. Tripathi)

Nine forage crop sequences maize + cowpea-berseem, M. P. Chari-berseem *Pennisetum pedicellatum* + guar-berseem, maize-lucerne, M. P. Chari-lucerne *Pennisetum pedicellatum* + lucerne, maize + guar-oat, M. P. Chari + guar-oat and *Pennisetum pedicellatum* + cowpea-oat were evaluated for production potential and comparative economics. Maximum forage yield (1249.5 q/ha), net profit (Rs. 14632.93/ha), return per rupee of investment (Rs. 1.87) and minimum cost of production per quintal of green forage (Rs. 6.25) were obtained with *Pennisetum pedicellatum* + guar-berseem rotation followed by M. P. Chari-berseem crop sequence which recorded 1182 q/ha, Rs. 13612.67, Rs. 1.91 and Rs. 6.72 green forage, net profit, return per rupee of investment and cost of production per quintal of green forage respectively.

6. **Economic studies of intercrops and nitrogen levels on fodder production of winter maize**

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

The experiment was conducted by Agronomy Division to study the economic and optimum dose of nitrogen for alone and mixed cropping of maize. The treatment consisted of maize alone, maize + oat-single cut, maize + oat-two cuts, maize + bajra and maize + tivra with three levels of nitrogen (40, 80 and 120 Rs. N/ha),

The dose response relationship for forage production was quadratic for all maize and its crop mixtures. The percentage of variation explained due to fitted relationship was over 99% in all cases.

Agronomic and economic optimum dose for green forage production, utilization of
nitrogen, cost of production, net profit, input output ratio and net profit was maximum in maize + bajra (Table-31).

1.5 Production and marketing of Forages in Jhansi District

(Mallayya and I. P. S. Yadav)

For this study 5 villages viz, Chirula, 2. Pahari 3. Kot 4. Pahalgaon and 5. Bhojala and various places of Jhansi City, fodder markets have been selected by purposive sampling. The data on kharif have been collected on maize, napier local grasses, bajra, chari and weeds for forages at various fodder market of Jhansi.

1.6 Evaluation of grassland production system for economic sheep production (Mutton/Wool)

(Mallayya and I. P. S. Yadav)

The study on the economic aspects of different grasses and legumes were undertaken in this project, 7 hectares of land was brought under cultivation by introduction of various grasses and legumes. The data were collected on various inputs and being analysed.

1.7 Techno-economic constraints, influencing production and productivity of important food and fodder crops, in Jhansi District

(R. A. Singh and I. P. S. Yadav)

The survey study conducted to work out the levels of investment, productivity and net returns for the adopted and non-adopted villages in Jhansi District. In all, 100 farmers were selected in which 38 from adopted villages and 41 from non-adopted villages grew the wheat crop.

In demonstrated villages, the average production of wheat and straw on 38 farmers field in 122.36 ha area were 24.77 and 40.92 q/ha, respectively. The cost of production worked out to be Rs. 4626.14/ha with net return of Rs. 1968.98/ha. The input–output ratio was 1:1.43. The different input costs involved in cultivation of wheat like seed, manure and fertilizer, human labour, bullock labour, tractor power, rent and revenue and other charges accounted for 6.52, 18.19, 12.07, 16.40, 6.43, 6.91, 22.41 and 10.80 percent respectively.

In case of non demonstrated villages the average production of wheat grain and
Table 31: Agronomic, economic optimum dose, nitrogen utilization efficiency and economics of the maize crops & mixed crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Agronomic optimum dose (kg/ha)</th>
<th>Economic optimum dose (kg/ha)</th>
<th>Nitrogen utilization efficiency</th>
<th>Cost of production (Rs/ha)</th>
<th>Net Profit (Rs/ha)</th>
<th>Input Output Ratio</th>
<th>Cost (Rs/q) green fodder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>111.35</td>
<td>104.53</td>
<td>1.30</td>
<td>1.05</td>
<td>3451.83</td>
<td>1:1.37</td>
<td>10.93</td>
</tr>
<tr>
<td>Maize + Oat (single cut)</td>
<td>102.90</td>
<td>94.97</td>
<td>0.94</td>
<td>0.67</td>
<td>3516.72</td>
<td>1:1.27</td>
<td>11.85</td>
</tr>
<tr>
<td>Maize + Oat (two cut)</td>
<td>103.63</td>
<td>98.09</td>
<td>1.37</td>
<td>0.99</td>
<td>3627.54</td>
<td>1:1.10</td>
<td>13.85</td>
</tr>
<tr>
<td>Maize + Batra</td>
<td>113.02</td>
<td>106.30</td>
<td>1.37</td>
<td>0.99</td>
<td>3627.54</td>
<td>1:1.50</td>
<td>9.98</td>
</tr>
<tr>
<td>Maize + Tivra</td>
<td>107.19</td>
<td>102.89</td>
<td>1.90</td>
<td>1.46</td>
<td>3430.22</td>
<td>1:1.45</td>
<td>10.31</td>
</tr>
</tbody>
</table>
straw on 41 farmers field in 66.96 ha area were 20.01 q/ha and 32.33 q/ha. The average cost of production of wheat was Rs. 4221.18 and net return was Rs. 757.84/ha. The input-output ratio was 1:1.18

Two type of relationship, namely multiple linear regression and Cobb-Douglas production function were fitted to the data. The fitted relationship including the coefficient of determination (R²) are given below separately for demonstrated and non-demonstrated villages.

\[
Y = 824.52 X_1^{0.0931} X_2^{0.1192} X_3^{0.0528} X_4^{0.0512} X_5^{0.0257} \\
(0.104) \quad (0.059) \quad (0.018) \quad (0.080) \quad (0.032) \quad R^2=0.376
\]

\[
Y = 8.89 X_1^{-0.0456} X_2^{0.2779} X_3^{0.0740} X_4^{0.2703} X_5^{0.0602} \\
(0.200) \quad (0.109) \quad (0.039) \quad (1.306) \quad (0.140) \quad R^2=0.357
\]

The Cobb-Douglas production function is better fitted than the multiple linear function. The Cobb-Douglas functions explains about 38% (demonstrated) and 36% (non-demonstrated) variation.

The production elasticities for various inputs varied from 0.0257 to 0.1192 for demonstrated villages and -0.0456 to 0.2779 for non-demonstrated villages. The marginal value productivity of different inputs indicated that marginal value of productivity of seed, manures, fertilizer, irrigation, human labour, bullock and tractor power would return Rs. 2.01, 0.99, 1.03, 0.37, 0.37 and 0.29 an additional output for the demonstrated farmers and Rs. 0.70, 2.19, 1.34, 1.69 and 0.55 gave an additional output for non-demonstrated farmers.

1.4 Impact of integrated development of Lakara and Karari watershed on rural economics

(R. A. Singh)

The village covered under this project were Lakara, Karari and Rund Karari. Lakara village has 75.6 ha forest area and Rund Karari and Karari villagea have no forest area. The Panchayat land, used as a community grazing land, in Rund Karari, Lakara and Karari villages is 28.4 ha, 6.4 ha and 80.0 ha, respectively. Mostly irrigated land is under well irrigation which is not sufficient to meet out the full requirement of all the crops. The maximum area of these villages has red soil (*rakar*).

The farmers of these three villages were devide in six categories big (6 ha), upper medium (4-6 ha), lower medium (2-4 ha), small (1-2 ha), marginal (upto 1 ha) and landless
according to size of holdings per household to see the economic and social differences in the farming communities.

In rabi, wheat and gram occupied 64% of the gross cropped area, while in kharif groundnut, soybean, jowar, urd, moong and maize covered about 30% of the cultivated area. The fodder crop berseem was grown in 0.6% of the gross cropped area.

Wheat: On the basis of area, total production and productivity, wheat is the most important crop in these three villages. The average production of wheat 19.10 q/ha closely compared with the National and State levels of wheat yield (18.60 q/ha).

Two types of relationship; namely multiple linear regression and Cobb-Douglas production function, were fitted to the wheat data.

The fitted production function indicated that the Cobb-Douglas production function is better fitted than the multiple linear function. The Cobb-Douglas function explained about 26 to 99% variation in R² whereas the multiple linear is better fit for only marginal farmers showing 40% against, 26% of Cobb-Douglas function and it explained 26% to 40% of variation 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 (deviation from zero) for different villages and for different categories of the farmers of project villages. Cobb-Douglas function elasticity for irrigation alone for Lakara and Karari village, seed, fertilizer and manure were found significant for Rund Karari village.

In the case of marginal farmers, multiple linear regression function was a better fit with the coefficient of determination 0.101 as against 0.258 for the Cobb-Douglas function. Elasticity of fertilizer and manure for marginal and small categories of farmers were found significant at 5% level. The elasticities of bullock/tractor and irrigation for lower medium farmers, bullock/tractor, irrigation and seed for upper medium farmers and only irrigation for big farmers were found significant.

Gram: Gram is the next important crop grown in 265 ha. Average productivity was 6.59 q/ha; which was lower than the national average of 7.41 q/ha.

Due to severe drought conditions and failure of rain during kharif 1986, the farmers received very poor yield from crops, like maize, groundnut, til, urd and moong, paddy was fully damaged due to drought.

Jowar: On the basis of the area in kharif, jowar, jowar-arhar are the most important crop in two villages viz. Lakara and Karari occupying 115.14 ha. of the gross cropped area.
Table-32 : Percentage of land distribution in relation to total of the village

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Lakara</th>
<th>Karari</th>
<th>Rund Karari</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Agricultural Land</td>
<td>71.80</td>
<td>63.16</td>
<td>58.72</td>
<td>65.25</td>
</tr>
<tr>
<td>Cultivated Land</td>
<td>57.37</td>
<td>46.39</td>
<td>40.02</td>
<td>48.68</td>
</tr>
<tr>
<td>Irrigated Land</td>
<td>27.23</td>
<td>30.21</td>
<td>20.56</td>
<td>26.82</td>
</tr>
<tr>
<td>Unirrigated Land</td>
<td>29.63</td>
<td>16.18</td>
<td>19.46</td>
<td>21.87</td>
</tr>
<tr>
<td>Cultivable Waste Land</td>
<td>25.22</td>
<td>33.50</td>
<td>55.34</td>
<td>35.71</td>
</tr>
<tr>
<td>Others</td>
<td>17.92</td>
<td>20.11</td>
<td>4.63</td>
<td>15.61</td>
</tr>
</tbody>
</table>

Table-33 : Productivity of different crop under sample villages

<table>
<thead>
<tr>
<th>Crop</th>
<th>Lakara</th>
<th>Karari</th>
<th>Rund Karari</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>21.36</td>
<td>16.85</td>
<td>18.09</td>
</tr>
<tr>
<td>Gram</td>
<td>6.63</td>
<td>5.05</td>
<td>8.76</td>
</tr>
<tr>
<td>Wheat + Gram</td>
<td>---</td>
<td>13.10</td>
<td>2.50</td>
</tr>
<tr>
<td>Wheat + Mustard</td>
<td>---</td>
<td>---</td>
<td>20.43</td>
</tr>
<tr>
<td>Barley</td>
<td>25.00</td>
<td>---</td>
<td>17.50</td>
</tr>
<tr>
<td>Barley, Gram + Mustard</td>
<td>8.33</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Berseem</td>
<td>687.63</td>
<td>536.03</td>
<td>---</td>
</tr>
<tr>
<td>Pea Pools</td>
<td>---</td>
<td>---</td>
<td>5.0</td>
</tr>
<tr>
<td>Pea Seed</td>
<td>---</td>
<td>---</td>
<td>2.0</td>
</tr>
</tbody>
</table>
Groundnut: Groundnut covered 89.02 ha, land (44.28 ha. in Rund Karari, 1.08 ha. in Lakara and 43.16 ha. in Karari) with a total 472 quintal

Table-34. Production (q/ha) and economics of wheat in sample villages

<table>
<thead>
<tr>
<th>Village</th>
<th>Production q/ha</th>
<th>Cost of production Rs.</th>
<th>Net returns Rs.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grain</td>
<td>Phusa</td>
<td></td>
</tr>
<tr>
<td>Lakara</td>
<td>21.36</td>
<td>35.80</td>
<td>5186.95</td>
</tr>
<tr>
<td>R. Karari</td>
<td>18.09</td>
<td>31.19</td>
<td>4739.77</td>
</tr>
<tr>
<td>Karari</td>
<td>16.85</td>
<td>31.42</td>
<td>4624.87</td>
</tr>
<tr>
<td>Average</td>
<td>19.10</td>
<td>34.41</td>
<td></td>
</tr>
</tbody>
</table>

REB-2 BIOMETRICAL STUDIES IN FORAGE PRODUCTION AND UTILIZATION

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

(Ashok Kumar and C. R. Hazra)

Secondary data obtained on dry matter yield, soil crust strength (SCS), seedling emergence (SE) and soil moisture content (SMC) for different forage crops viz-maize, pearl millet, cowpea, guar and sorghum, repeated at two consecutive years, have been utilized. Several yield prediction (linear and multiple) regression functions were evaluated and optimum prediction have been decided on the basis of validity of fitness (R^2) and standard error of regression.

Yield prediction of different forage crops for different soil parameters revealed that the regression of yield on SE was found better in comparison to square root and logarithmic for cowpea, guar and sorghum. Logarithmic yield prediction equation for SMC was found superior over linear and square root for guar, on the other hand, for cowpea and sorghum, it assumed linear relationship. The prediction function of yield on SCS was linear, logarithmic and square root for cowpea, guar and sorghum respectively. Taking forage
crop as a whole, the regression of dry matter yield w.r.t. the above soil parameters shows logarithmic function as superior one in comparison with square root and linear. SCS was proved to be an important character for optimum prediction in crops viz-maize, pearl millet and cowpea while SE in case of guar, sorghum and forage crop as whole, with good precision.

Multiple regression of dry forage yield with respect to SE, SCS and SMC revealed that the square root and logarithmic equation were better for maize and pearl millet respectively while linear in case of guar, cowpea and sorghum. Logarithmic function was found better in comparison with linear and square root for yield prediction of forage crops as a whole for different soil parameters.

Evaluated optimum yield prediction equations for various forage crops are as follows:

Guar: \[ Y = 45.9532 - 0.3299 X_1 - 2.4789 X_2 - 0.1759 X_3 \] \[ R^2 = 0.3391 \]

Cowpea: \[ Y = 66.6668 + 0.2369 X_1 - 5.8242 X_2 - 0.0633 X_3 \] \[ R^2 = 0.3391 \]

Maize: \[ Y = 5.3166 + 0.2538 X_1^{1/2} - 0.7781 X_2^{1/2} - 0.5999 X_3^{1/2} \] \[ R^2 = 0.6155 \]

Pearl Millet: \[ \ln Y = 5.1176 + 0.2204 \ln X_1 - 0.4534 \ln X_2 + 1.2040 \ln X_3 \] \[ R^2 = 0.2438 \]

Sorghum: \[ Y = 4.3258 + 0.1453 X_1 - 1.3078 X_2 + 0.2038 X_3 \] \[ R^2 = 0.7659 \]

Overall: \[ \ln Y = 0.5181 + 1.0288 \ln X_1 - 0.0469 \ln X_2 + 0.2374 \ln X_3 \] \[ R^2 = 0.5455 \]

Where, \[ Y \]: Dry forage yield (kg/plut)
\[ X_1 \]: Seedling emergence (No./plot)
\[ X_2 \]: Soil crust strength (kg/plot)
\[ X_3 \]: Soil moisture content (%)

Significant at .01 level

Figures in parenthesis are S.E. (regression coefficient)
2.4 Distribution of yields in relation to size and shape of plots in forage crops

(Ashok Kumar and S. K. Rajpali)

Data already collected under the project entitled “Uniformity trials on forage crops” for M. P. Chari, cowpea, lucern, stylo, oat, natural grasses and berseem have been scrutinised and tabulated as per desired format for analysis for each crop.

Frequency distribution were obtained for cowpea and M. P. Chari, different measures of variations viz-% C.V., skewness, kurtosis etc, were determined. Study reveals, with the increase in block size resulted in reduction of percent variability in yield but kurtosis of the distribution of yield was away from the normality. The variability in the distribution of yield of cowpea ranges from 47.46% to 11.50% while in M. P. Chari, it was from 32.89 to 8.96%. By and large, the shape of plots did not show any consistent effect on normality but nearly square plots are very much near with normality.
DIVISION OF EXTENSION AND TRAINING

Extm. 1. ADOPTION AND DIFFUSION OF FORAGE INNOVATION AND FEED BACK INFORMATION

1.1 Studies on the factors (socio-economic, psychological and communication) associated with adoption behaviour of Bundelkhand farmer

As a result of transfer of Dr. M. R. Lokhande, the then project leader, this project has to be reinitiated in order to study the differential characteristics (socio-economic psychological and communication) of adopters and non-adopters of forage crops. The detail questionnaire is to be prepared.

1.2 A study of information source utilization patterns of big and small farmers in relation to forage crops.

This project is also to be reinitiated as Dr. M. R. Lokhande has been transferred from this Institute. The detail questionnaire schedule in relation to source utilization patterns of farmers is to be prepared.

1.3 Attitude of small and marginal farmers on adoption of fodder crops in Jhansi District

(Maharaj Singh)

The project has been completed this year and important findings are as follows:

(i) The farmers of this area has started realizing importance of forage crops as evident from favourable attitude of farmers (88%) towards growing of fodder crops.

(ii) Study revealed that 30.7% of small and marginal farmers are adopting fodder crops on 3.4% of their land area.

(iii) The average feed supplemented by small and marginal farmers was comprised of 4.20, 4.62 kg green fodder, 2.54, 2.58 kg dry matter and 0.14, 0.10 kg concentrate per day per animal, respectively.

(iv) The average livestock size was 4.2 and 2.4 with small and marginal farmers, respectively.
1.4 Lakara–Karaîi Watershed– a cross sectional analysis of the farmers for rural extension studies

(Maharaj Singh and Mahavir Singh)

The questionnaire schedule has been prepared and data collection is in progress. The benchmark survey for related aspects of this project has been completed in major watershed area. The survey conducted for landless, small and marginal, medium and big farmers revealed that socio-economic status of landless labours is very poor. The small and marginal farmers are better compared to landless while medium and big farmers has good standard of living enjoying maximum credit facilities from banks etc. but still irrigation water and improved implements are main constraints.
INTER-INSTITUTIONAL COLLABORATIVE RESEARCH PROJECT

The institute initiated the collaborative research project on Farming system with the research Institutes viz. IVRI, Izatnager; CIRG, Makhdoom; CSWRI, Avikanagar; CAZRI Jodhpur and ICAR Research Complex for NEH Region, Shillong during the year 1986. The technical programme was developed and work was initiated from kharif 1987. Due to unprecedented drought, only part of the technical programme could be implemented. Studies conducted at IGFRI, Jhansi are presented below:

a) Fodder-Milk Production system:

This project was initiated at IVRI, Izatnager and IGFRI, Jhansi. In this, intensive fodder cultivation for supplying green fodder throughout the year was taken up.

In kharif 1987, annual crop of sorghum and cowpea was grown at Jhansi. In perennial system, Hy-napier grown in the previous season was superimposed with cowpea this year. Details of input given per unit land, green fodder, input-output ratio was worked out and presented in (Table 35).

Table-35. Production and economics of the crops.

<table>
<thead>
<tr>
<th>Name of crops</th>
<th>Yield (q/ha)</th>
<th>Expenditure (Rs/ha)</th>
<th>Cost (Rs/ha)</th>
<th>Market value (Rs/ha)</th>
<th>Input output ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sorghum (PC-6)</td>
<td>298</td>
<td>1782.80</td>
<td>5.98</td>
<td>3576.80</td>
<td>1:2.01</td>
</tr>
<tr>
<td>2. Hy napier + Cowpea (R. gaint)</td>
<td>409.5</td>
<td>1774.25</td>
<td>4.35</td>
<td>6142.50</td>
<td>1:3.45</td>
</tr>
</tbody>
</table>

Milk production studies would be started from 1988. Experimental animals have been obtained from IVRI.
b) **Soil–Water–Plant–Livestock Management system**:

In this system, 18 ha land has been taken. 4 ha each has been allotted to (a) 3 tier forage production, (b) sown pasture (c) improved pasture (d) natural pasture and (e) 2 ha has been kept as control (bare land). In each field, soil losses and run off has been recorded. Due to severe drought in 1987, forage in all the system could not be established as per schedule, but 3-tier system and sown pasture area has been established.
During 1987 the research farm of the regional station was shifted from Manasbal to K. D. Farm, Srinagar. The research work was initiated at the new farm in May, 1987. Besides following experiments, an area of 6 acres was sown under general crops of cowpea, maize, M. P. Chari, teosinte and sorghum. Since irrigation is not available at the farm, the crops did not perform well. Though the germination was good in most of the crops, subsequent survival was not more than 20 per cent. The further growth was also poor due to inadequate irrigation. A total of 5.91 q of hay was produced, 75 kg of cowpea (cv NP-3) and 18 kg of cowpeas (cv 450) seeds were also produced.

**NRS-1 : COLLECTION, EVALUATION AND INTRODUCTION OF NON-CONVENTIONAL FODDER PLANTS IN NORTH-WESTERN TEMPERATE HIMALAYAS**

1.1 Evaluation of some buckwheat collections for their possible introduction as short duration fodder crops

(B. K. Misri)

Buckwheat (*Fagopyrum*) has long been cultivated for grain in higher reaches of the Himalayas. In some parts of Ladakh this is cultivated as a second crop during a short summer. Incase the weather does not permit the crop to mature, it is harvested and used as a fodder. Six collections were made from Ladakh and another 13 collections were procured from the Botany Department of Kashmir University. All the collections were sown in single plots on 14–5–87. The performance of all these collections as fodder crops is given in (Table–36). Maximum green fodder yield of 343.2 q/ha was achieved in case of *Fagopyrum tataricum*. Cultivar *botansoba* came into 50% flowering stage within 24 days of its sowing. The results achieved indicate that *Fagopyrum* can be cultivated as a short duration fodder crop before the regular sowing of either kharif or rabi crops.

**NRS-2 : CULTIVATION OF FODDER CROPS ON KAREWA LANDS UNDER UNIRRIGATED CONDITIONS**

2.1 Performance of various grass-legume mixtures

(B. K. Misri)
<table>
<thead>
<tr>
<th>Accessions of Buckwheat</th>
<th>Days taken to 50% flowering</th>
<th>Average height of plants (cm)</th>
<th>Average no. of leaves/plants</th>
<th>Leaf weight/plant (g)</th>
<th>Stem weight/plant (g)</th>
<th>Green Fodder Yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Green</td>
<td>Dry</td>
<td>Green</td>
</tr>
<tr>
<td>Cv. Botansoba</td>
<td>24</td>
<td>56.0</td>
<td>34.0</td>
<td>5.0</td>
<td>2.31</td>
<td>9.0</td>
</tr>
<tr>
<td>Cv. Hrusozowska</td>
<td>27</td>
<td>41.4</td>
<td>18.2</td>
<td>2.4</td>
<td>0.91</td>
<td>6.2</td>
</tr>
<tr>
<td>Cv. Siva</td>
<td>27</td>
<td>40.7</td>
<td>30.2</td>
<td>4.2</td>
<td>1.97</td>
<td>9.0</td>
</tr>
<tr>
<td>Cv. Shinanu</td>
<td>42</td>
<td>26.2</td>
<td>41.5</td>
<td>9.0</td>
<td>3.62</td>
<td>9.5</td>
</tr>
<tr>
<td>Cv. Bednja</td>
<td>27</td>
<td>47.9</td>
<td>22.6</td>
<td>6.0</td>
<td>1.43</td>
<td>10.6</td>
</tr>
<tr>
<td>Sp. Kashmiranum</td>
<td>33</td>
<td>59.4</td>
<td>69.4</td>
<td>9.2</td>
<td>5.44</td>
<td>12.6</td>
</tr>
<tr>
<td>Cv. Shinanovoosoba</td>
<td>44</td>
<td>66.2</td>
<td>27.0</td>
<td>11.4</td>
<td>3.85</td>
<td>18.7</td>
</tr>
<tr>
<td>Cv. Kyushuakisoba</td>
<td>51</td>
<td>20.8</td>
<td>12.2</td>
<td>4.5</td>
<td>1.06</td>
<td>3.70</td>
</tr>
<tr>
<td>Sp. esculentum</td>
<td>38</td>
<td>86.0</td>
<td>60.8</td>
<td>9.8</td>
<td>4.80</td>
<td>12.4</td>
</tr>
<tr>
<td>Cv. Adachis race</td>
<td>38</td>
<td>79.0</td>
<td>29.6</td>
<td>8.2</td>
<td>3.48</td>
<td>13.2</td>
</tr>
<tr>
<td>Sp. sagitatum</td>
<td>49</td>
<td>44.6</td>
<td>55.2</td>
<td>5.8</td>
<td>2.58</td>
<td>7.2</td>
</tr>
<tr>
<td>Sp. tataricum (IC-18889)</td>
<td>52</td>
<td>36.8</td>
<td>98.3</td>
<td>18.6</td>
<td>6.30</td>
<td>24.3</td>
</tr>
<tr>
<td>Cv. Kulu (Gangart)</td>
<td>75</td>
<td>26.5</td>
<td>118.5</td>
<td>12.5</td>
<td>3.80</td>
<td>22.5</td>
</tr>
<tr>
<td>86-39</td>
<td>48</td>
<td>63.9</td>
<td>69.2</td>
<td>4.6</td>
<td>1.79</td>
<td>7.0</td>
</tr>
<tr>
<td>86-75</td>
<td>61</td>
<td>35.2</td>
<td>125.4</td>
<td>6.2</td>
<td>2.13</td>
<td>6.2</td>
</tr>
<tr>
<td>86-72</td>
<td>64</td>
<td>25.7</td>
<td>111.2</td>
<td>6.2</td>
<td>3.20</td>
<td>6.2</td>
</tr>
<tr>
<td>86-35</td>
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<td>53.4</td>
<td>9.4</td>
<td>4.34</td>
<td>22.8</td>
</tr>
<tr>
<td>86-36</td>
<td>23</td>
<td>86.6</td>
<td>35.6</td>
<td>4.6</td>
<td>1.30</td>
<td>11.4</td>
</tr>
<tr>
<td>86-20</td>
<td>24</td>
<td>83.8</td>
<td>34.4</td>
<td>5.6</td>
<td>1.58</td>
<td>13.0</td>
</tr>
</tbody>
</table>
Karawas are high table lands, found widely spread in the Kashmir valley. These lacustrine deposits are flat or slopy lands with very poor moisture retention capacity. Being higher in elevation, it is difficult to provide irrigation in these areas. Consequently, rice, the main crop of Kashmir, can not be grown here. Such areas are suitable for the cultivation of fodders in Kashmir, where cultivable land is almost unavailable for fodder cultivation.

Maize, teosinte, M. P. Chari and sorghum were sown as a pure crops and in combination with cowpea cv. NP-3, cowpea cv. 450 and guar. All the combinations were sown in a R. B. D. experiment. Due to heavy rains during May, 1987 the whole experiment got submerged under water and a crust was formed on the plots, thereby making the germination very erratic. Though maize, M. P. Chari sorghum and cowpeas germinated and performed well, guar, teosinte exhibited very erratic germination and stunted growth. Teosinte could not come to flowering stage till Nov, when it was harvested. Results obtained under this experiment were quite erratic because of mechanical disturbances due to rains and subsequent crust formation. However, useful information with respect to the cultivation of these fodder crops on Karewa. was collected. Maximum yield of 109.3 q/ha (F.W) was achieved in maize, it was followed by 100.9 q/ha (F. W) in case of maize + guar. Minimum yield of 27.8 q/ha (F.W) was achieved in case of teosinte + guar. Maximum dry weight of 54.10 q/ha was achieved in case of maize while it was minimum in case of M. P. Chai + cowpeas NP-3 (16.71 q/ha). It was also observed under this experiment that under Kashmir conditions cowpeas NP-3 is not a suitable legume component since it matures well before the grass components could mature. However, cultivar-450 is late maturing and is a suitable legume component.

2.2 Effect of various spacing 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 (R1, R2, R3, R4) were combined with four line to line spacing of 20, 30, 40, 50 cm (S1, S2, S3, S4) in a R.B Design to find the best combination for maximum seed production in cowpea cv. NP-3. The result obtained are given in (Table-37).

Statistically it was found that spacings do not have any significant effect on seed production. A spacing of 30 cm between lines and a seed rate of 20 kg/ha was found to be the best combination.
Table 37. Effect of various spacings and seed rates on seed production in Cowpea NP-3 (q/ha).

<table>
<thead>
<tr>
<th>Line to line spacing (cm)</th>
<th>Seed rate (kg/ha)</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td></td>
<td>5.27</td>
<td>5.20</td>
<td>5.18</td>
<td>6.11</td>
<td>5.44</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>7.15</td>
<td>8.91</td>
<td>7.32</td>
<td>6.37</td>
<td>7.43</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>5.32</td>
<td>4.92</td>
<td>4.91</td>
<td>5.07</td>
<td>5.05</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>5.49</td>
<td>6.00</td>
<td>5.71</td>
<td>5.21</td>
<td>3.60</td>
</tr>
</tbody>
</table>

NRS-3. COLLECTION, EVALUATION AND INTRODUCTION OF EXOTIC FORAGE GERMPLASMS

3.1 Evaluation of some exotic collections of Medicago

(B. K. Mishri)

26 collections of *Medicago* received from NBPGR were evaluated. The results obtained are presented in (Table 38). Maximum fodder yield was obtained in collection No. EC 190432. Collection EC 190428 was the earliest to achieve 50% flowering in 68 days. Two collections, EC 159363 and EC 159368 were transplanted from Manasbal farm.
REGIONAL STATION, AVIKANAGAR (RAJASTHAN)

The Western Regional Research Station was established in about 80 ha. of land at the Central Sheep & Wool Research Institute, Avikanagar in November 1986 to cater the needs of arid and transitional semi-arid regions and came into functional existence w.e.f. 2.2.1987. The vegetation in these regions is very poor which can hardly support small ruminants like sheep and goats. This station will carry the research on all aspects of production and utilization of grasses, grasslands and fodder crops. The Western Regional Research Station, Avikanagar is located at 26°N 75.2°E at the height of 326 meters above MSL.

The Centre was inaugurated by Hon'ble Union State Minister for Agriculture, Shri Yogendra Makwana on 21st September, 1987. The State Minister for Animal Husbandry, Govt. of Rajasthan also graced the function. Other distinguished guests were Member of Parliament for Tonk Distt. Shri B. L. Bairwa, Dr. R. M. Acharaya, D.D.G. (Animal (Sciences), ICAR and Dr. A. L. Choudhary, Director, CSWRI, Avikanagar.

Fertility status of the farm

80 hectare of farm area was classified into 5 sub groups. The soil samples collected from these groups were analysed for its fertility status from soil testing laboratory, Govt. of Rajasthan, Jaipur. The details of soil analysis is given in (Table-39).

Climatic parameters

During the year 1987 (Feb.–Dec.) total monthly variation in temperature, relative humidity, rain fall, wind velocity, evaporation, soil temperature (5, 10 and 15 cm. depth) and average sunshine were recorded. The hottest month was June (460C) followed by May and April (44.10C). The average rainfall during the year was in general very low. A total of 342.9 mm. rainfall was recorded during the year. However, this year was a drought year as compared to normal rainfall in the region. The minimum RH % was recorded in the month of April and May (Table-40).
Table 38: Evaluation of some exotic collections of *Medicago*

<table>
<thead>
<tr>
<th>Acc. No.</th>
<th>Days taken to 50% flowering</th>
<th>Plant height (cm)</th>
<th>Fodder yield (g) in 4m row</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Green</td>
</tr>
<tr>
<td>EC 159363</td>
<td>38</td>
<td>40.8</td>
<td>68</td>
</tr>
<tr>
<td>EC 159368</td>
<td>51</td>
<td>59.6</td>
<td>230</td>
</tr>
<tr>
<td>EC 190433</td>
<td>79</td>
<td>50.5</td>
<td>220</td>
</tr>
<tr>
<td>EC 190437</td>
<td>89</td>
<td>67.3</td>
<td>257</td>
</tr>
<tr>
<td>IC 190429</td>
<td>72</td>
<td>70.2</td>
<td>438</td>
</tr>
<tr>
<td>EC 190442</td>
<td>85</td>
<td>62.6</td>
<td>329</td>
</tr>
<tr>
<td>EC 190444</td>
<td>77</td>
<td>56.2</td>
<td>442</td>
</tr>
<tr>
<td>EC 190466</td>
<td>77</td>
<td>55.4</td>
<td>391</td>
</tr>
<tr>
<td>EC 190432</td>
<td>74</td>
<td>49.9</td>
<td>465</td>
</tr>
<tr>
<td>IC 190428</td>
<td>68</td>
<td>60.4</td>
<td>460</td>
</tr>
<tr>
<td>EC 190427</td>
<td>80</td>
<td>50.4</td>
<td>220</td>
</tr>
<tr>
<td>EC 190431</td>
<td>70</td>
<td>56.4</td>
<td>315</td>
</tr>
<tr>
<td>EC 190435</td>
<td>74</td>
<td>50.5</td>
<td>137</td>
</tr>
<tr>
<td>EC 190440</td>
<td>79</td>
<td>50.8</td>
<td>318</td>
</tr>
<tr>
<td>EC 190439</td>
<td>80</td>
<td>51.5</td>
<td>355</td>
</tr>
<tr>
<td>EC 190434</td>
<td>74</td>
<td>53.1</td>
<td>294</td>
</tr>
<tr>
<td>EC 190430</td>
<td>73</td>
<td>61.7</td>
<td>342</td>
</tr>
<tr>
<td>EC 190426</td>
<td>83</td>
<td>44.1</td>
<td>175</td>
</tr>
<tr>
<td>EC 190425</td>
<td>81</td>
<td>54.1</td>
<td>175</td>
</tr>
<tr>
<td>EC 190423</td>
<td>91</td>
<td>49.7</td>
<td>266</td>
</tr>
<tr>
<td>EC 190424</td>
<td>83</td>
<td>49.3</td>
<td>225</td>
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<tr>
<td>EC 190422</td>
<td>81</td>
<td>42.3</td>
<td>239</td>
</tr>
<tr>
<td>EC 190418</td>
<td>84</td>
<td>45.4</td>
<td>75</td>
</tr>
<tr>
<td>EC 190419</td>
<td>81</td>
<td>51.8</td>
<td>92</td>
</tr>
<tr>
<td>EC 190420</td>
<td>79</td>
<td>59.8</td>
<td>95</td>
</tr>
<tr>
<td>EC 190421</td>
<td>79</td>
<td>49.0</td>
<td>135</td>
</tr>
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</table>
Table-39 : Soil analysis of the farm area

<table>
<thead>
<tr>
<th>Site</th>
<th>pH</th>
<th>Conductivity</th>
<th>Org. carbon (%)</th>
<th>P (kg/h)</th>
<th>K (kg/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8.1</td>
<td>0.2</td>
<td>0.10</td>
<td>13.0</td>
<td>160</td>
</tr>
<tr>
<td>2</td>
<td>7.8</td>
<td>0.1</td>
<td>0.16</td>
<td>30.0</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>7.5</td>
<td>0.1</td>
<td>0.19</td>
<td>22.0</td>
<td>170</td>
</tr>
<tr>
<td>4</td>
<td>7.4</td>
<td>0.1</td>
<td>0.08</td>
<td>16.0</td>
<td>140</td>
</tr>
<tr>
<td>5</td>
<td>7.6</td>
<td>0.1</td>
<td>0.16</td>
<td>39.0</td>
<td>150</td>
</tr>
</tbody>
</table>

WRS-1 EVALUATION OF FORAGE CROPS

1.1 Evaluation trial on guar for seed production

(Fateh Singh and R. K. Jain)

The fifteen strains of guar were tried in a randomised block design to test their suitability for seed production. The highest grain yield (12.9 q/ha) was recorded with IGFRI 2395-2 followed by IGFRI 212-1, 1538-1, 579-1, HG-75 and HG-119. The difference amongst the above strains were not significant. However, the variety IGFRI-1019-1 produced the lowest grain yield. The highest number of pods per plant were recorded with HG-75 followed by IGFRI-212-1. The more number of leaves per plant were observed with IGFRI-1539-1 followed by IGFRI-2395-1. Highest plant height was recorded with IGFRI-212-1 (Table-41).

1.2 Evaluation trial on guar for fodder production

(Fateh Singh and R. K. Jain)

An experiment was conducted on light soil during kharif 1987 to evaluate the varietal performance for higher fodder production. The twelve varieties were tested in a
Table-40 : Average monthly variation in temperature, relative humidity, rainfall, wind velocity, evaporation, soil temperature and sunshine during the year 1987

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean temp.</th>
<th>°C Min.</th>
<th>Relative Humidity</th>
<th>Rainfall (mm.)</th>
<th>Wind velocity (kg/hour)</th>
<th>Evaporation</th>
<th>Soil-temp. in depth (°C)</th>
<th>Sunshine</th>
</tr>
</thead>
<tbody>
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<td>January</td>
<td>28.1</td>
<td>1.5</td>
<td>75.7</td>
<td>38.6</td>
<td>1.0</td>
<td>2.9</td>
<td>3.4</td>
<td>20.2</td>
</tr>
<tr>
<td>January</td>
<td>31.7</td>
<td>5.6</td>
<td>71.9</td>
<td>27.7</td>
<td>—</td>
<td>3.6</td>
<td>5.4</td>
<td>25.3</td>
</tr>
<tr>
<td>March</td>
<td>37.0</td>
<td>8.3</td>
<td>62.0</td>
<td>25.9</td>
<td>3.0</td>
<td>4.1</td>
<td>6.5</td>
<td>32.8</td>
</tr>
<tr>
<td>April</td>
<td>44.1</td>
<td>14.5</td>
<td>35.8</td>
<td>15.4</td>
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<td>4.7</td>
<td>11.7</td>
<td>40.3</td>
</tr>
<tr>
<td>May</td>
<td>44.1</td>
<td>19.0</td>
<td>48.3</td>
<td>19.9</td>
<td>15.8</td>
<td>5.9</td>
<td>11.3</td>
<td>42.1</td>
</tr>
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<td>21.8</td>
<td>78.9</td>
<td>30.3</td>
<td>39.4</td>
<td>6.2</td>
<td>12.1</td>
<td>43.1</td>
</tr>
<tr>
<td>July</td>
<td>42.0</td>
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<td>39.4</td>
<td>10.2</td>
<td>7.4</td>
<td>11.2</td>
<td>45.5</td>
</tr>
<tr>
<td>August</td>
<td>41.5</td>
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<td>78.2</td>
<td>55.0</td>
<td>189.2</td>
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<td>22.0</td>
<td>73.6</td>
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<td>52.4</td>
<td>3.3</td>
<td>7.7</td>
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</tr>
<tr>
<td>October</td>
<td>40.0</td>
<td>14.5</td>
<td>63.0</td>
<td>24.2</td>
<td>—</td>
<td>2.6</td>
<td>7.3</td>
<td>38.2</td>
</tr>
<tr>
<td>November</td>
<td>36.6</td>
<td>8.8</td>
<td>61.7</td>
<td>24.4</td>
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<td>1.3</td>
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</tr>
<tr>
<td>December</td>
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<td>78.5</td>
<td>42.3</td>
<td>32.0</td>
<td>1.5</td>
<td>2.8</td>
<td>21.2</td>
</tr>
<tr>
<td>Treatments</td>
<td>Grain yield (q/ha)</td>
<td>No. of pods per plant</td>
<td>No. of leaves per plant</td>
<td>Plant height (cm.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------</td>
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<td>-------------------------</td>
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<tr>
<td>1. IGFRI-2395-2</td>
<td>12.88</td>
<td>35.3</td>
<td>57.6</td>
<td>100.3</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>2. &quot; 1028-1</td>
<td>10.33</td>
<td>31.1</td>
<td>47.3</td>
<td>101.6</td>
<td></td>
<td></td>
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<tr>
<td>3. &quot; 212-1</td>
<td>12.66</td>
<td>37.2</td>
<td>53.8</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>4. &quot; 197-1</td>
<td>9.05</td>
<td>34.9</td>
<td>57.1</td>
<td>103.9</td>
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<tr>
<td>5. &quot; 1019-1</td>
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<td></td>
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</tr>
<tr>
<td>6. &quot; 24-1</td>
<td>10.54</td>
<td>30.1</td>
<td>48.7</td>
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<td>7. &quot; 23-1</td>
<td>10.66</td>
<td>31.0</td>
<td>49.8</td>
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<tr>
<td>8. &quot; 579-1</td>
<td>12.28</td>
<td>31.2</td>
<td>48.2</td>
<td>100.0</td>
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<td>10. &quot; 2402-1</td>
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<td></td>
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</tr>
<tr>
<td>11. &quot; 1539-1</td>
<td>11.66</td>
<td>29.3</td>
<td>57.8</td>
<td>100.8</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>12. &quot; 1538-1</td>
<td>12.28</td>
<td>33.7</td>
<td>51.3</td>
<td>103.7</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>13. &quot; 8-1</td>
<td>9.66</td>
<td>30.5</td>
<td>46.3</td>
<td>104.6</td>
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</tbody>
</table>
Randomized Block Design. The highest green and dry forage yields were recorded with HG-119 and it was closely followed by IGFRI 212-1 and HG-75. The above varieties produced significantly higher yield over IGFRI-23-1 and 23-11-1. The lowest green fodder yield was recorded with IGFRI-23-1. The remaining varieties produced the yield in between (Table 42).

Table 42: Green and dry forage yield of guar

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Green</th>
<th>Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. IGFRI—8-1</td>
<td>96.1</td>
<td>17.2</td>
</tr>
<tr>
<td>2. ″ 24-1</td>
<td>93.8</td>
<td>18.3</td>
</tr>
<tr>
<td>3. ″ 2395-1</td>
<td>111.6</td>
<td>21.2</td>
</tr>
<tr>
<td>4. ″ 109-1</td>
<td>97.8</td>
<td>16.2</td>
</tr>
<tr>
<td>5. ″ 859-1</td>
<td>110.4</td>
<td>19.5</td>
</tr>
<tr>
<td>6. ″ 212-1</td>
<td>115.4</td>
<td>25.5</td>
</tr>
<tr>
<td>7. ″ 579-1</td>
<td>109.4</td>
<td>16.7</td>
</tr>
<tr>
<td>8. ″ 23-1</td>
<td>91.1</td>
<td>17.8</td>
</tr>
<tr>
<td>9. ″ 2402-1</td>
<td>105.4</td>
<td>18.3</td>
</tr>
<tr>
<td>10. ″ 1028-1</td>
<td>103.3</td>
<td>16.2</td>
</tr>
<tr>
<td>11. HG—75</td>
<td>114.4</td>
<td>23.3</td>
</tr>
<tr>
<td>12. ″ 119</td>
<td>120.4</td>
<td>26.7</td>
</tr>
</tbody>
</table>

1.3 Evaluation trial on Cowpea

(Fateh Singh and R. K. Jain)

The variety NP-3 produced significantly higher green fodder yield overall the
varieties which were tested under experiment. This variety also produced more dry matter but the differences were not significant. The variety IGFRI-450 stood next in green and dry forage yield (Table-43)

Table-43: Green and dry forage yield

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Green</th>
<th>Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. UPC 5288</td>
<td>122.8</td>
<td>30.5</td>
</tr>
<tr>
<td>2. 6342</td>
<td>95.5</td>
<td>26.1</td>
</tr>
<tr>
<td>3. 287</td>
<td>103.8</td>
<td>28.3</td>
</tr>
<tr>
<td>4. IGFRI 450</td>
<td>123.8</td>
<td>31.1</td>
</tr>
<tr>
<td>5. UPC 9021</td>
<td>117.1</td>
<td>27.8</td>
</tr>
<tr>
<td>6. 9805</td>
<td>103.3</td>
<td>25.0</td>
</tr>
<tr>
<td>7. MFC 42-1</td>
<td>117.3</td>
<td>27.8</td>
</tr>
<tr>
<td>8. UPC 5287</td>
<td>113.3</td>
<td>27.8</td>
</tr>
<tr>
<td>9. NP 3</td>
<td>134.4</td>
<td>33.8</td>
</tr>
<tr>
<td>10. C 152</td>
<td>112.8</td>
<td>26.6</td>
</tr>
</tbody>
</table>

WRS-2: STUDIES ON AGRO-HORTI-SILVIPASTORAL SYSTEMS

2.1 Studies on saplings establishment

(Fateh Singh and R. K. Jain)

During the period under report the saplings of *Ailanthes exelsa*, *Dichrostachyes cinerea*, *Albizia lebbek*, *Dalbergia sissoo*, *Azadirchta indica* and *Prosopis cineria* were raised in polythylene bags and after four months these were transplanted in the field.
The survival percentage is given in (Table 44). The maximum establishment (94.8%) was recorded under *Dichrostachys cineria*.

**Observations on fuel fodder and yield/plant:** Data on fodder and fuel yield of 8 tree species transplanted in the area, were recorded in the month of November and are presented in the (Table 45). Maximum green leaves were harvested from *A. indica* (10 years old plant) and *A. exelsa* (7 years old plant) 53.0 and 51.5 kg/plant respectively and the least in *D. cineria* (5 years old plant) 7.0 kg/plant. The dry matter percentage was maximum in *D. cineria* 59% followed by Kheri 52% and least in *A. exelsa* 34% only.

The maximum height of 60.38 cm was recorded for *Azadirchta indica*, *Ailinthes exelsa* and *Albizia lebbek* showed least growth during this period. *Dalbergia sissoo* performed better.

### 2.2 Three tier system for agro-silvipastoral fodder production

(Fateh Singh and R. K. Jain)

A field trial in two hectare was laid down on three tier system of agro-silvipastoral fodder production system. The three components of the system are *A. exelsa*, *D. cineria* and *C. ciliaris*. *A. exelsa* was transplanted at 15m distance plant to plant in a row. Similarly, *D. cineria* was transplanted in alternate rows followed by *C. ciliaris* at 75 cm distance was transplanted. The plant growth parameters were recorded at 3 months interval. There was 80.4 and 94.8 per cent survival of *A. exelsa* and *D. cineria* respectively.

**Table-44 : Survival percentage and average plant growth of fodder trees**

<table>
<thead>
<tr>
<th>Plant spp.</th>
<th>Survival (%)</th>
<th>Plant height</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aleinthes exelsa</em></td>
<td>80.4</td>
<td>28.15</td>
</tr>
<tr>
<td><em>Dichrostachys nutens</em></td>
<td>94.8</td>
<td>35.06</td>
</tr>
<tr>
<td><em>Albizia lebbek</em></td>
<td>51.9</td>
<td>30.80</td>
</tr>
<tr>
<td><em>Dalbergia sissoo</em></td>
<td>88.8</td>
<td>51.37</td>
</tr>
<tr>
<td><em>Azadirchta indica</em></td>
<td>85.7</td>
<td>60.38</td>
</tr>
<tr>
<td><em>Prosopis cineria</em></td>
<td>46.3</td>
<td>34.90</td>
</tr>
</tbody>
</table>
WRS-3: STUDIES ON NEMATODES IN RELATION TO FORAGE CROPS

3.1 General survey
(R. K. Jain)

A general survey of the farm revealed that few of the diseases were most prevalent during this year in spite of severe drought. The insect problem was not a challenging though sporadic infection in few crops like cowpea, guar, sorghum and maize was recorded. The green ear diseases of bajra was observed in one particular field with an intensity of 0.5% on the basis of infected plants in a 5 x 5 m² area. Leaf spots of different nature were recorded in bajra, sorghum, maize in almost all the fields. The identification of the causal organisms was not done. Siris (Albizia lebbek) was observed to be heavily infested with rust during the month of Sept-Oct causing defoliation of the leaves.

Among the nematode problems in the area, root-knot caused by Meloidogyne spp. was observed at higher intensity. Cowpea, guar, maize, bajra, vegetables like tomato, bringal, cucurbits exhibit heavily knotted roots because of the light sandy soil this nematode caused heavy damage.

3.2 Screening of cowpea variety for resistance against M. incognita
(R. K. Jain)

Eleven elite selection alongwith C-152, reported resistant line of cowpea, were screened under pot condition with artificial inoculation and under field at natural condition. The infested soil from microplot were filled in the pots. The cowpea seed was planted and data were recorded after 45 days for the presence of galls on the root system and root knot index was calculated. This study revealed that selection IL 450 exhibited a similar reaction as expressed by C-152 i.e. tolerance, as number of galls production on these two lines were less and small. Under field condition no galls were observed on root system of any of the lines, indicating field was free from infestation (Table 46).

Table No. 45: Fuel-Fodder yield per plant (Average of 10 plants)

<table>
<thead>
<tr>
<th>Plant spp.</th>
<th>Fresh Wt. kg</th>
<th>Dry Wt. %</th>
<th>Fuel kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>D. nutans</td>
<td>7.0</td>
<td>59</td>
<td>8.5</td>
</tr>
<tr>
<td>A. exelsa</td>
<td>51.5</td>
<td>34</td>
<td>43.5</td>
</tr>
<tr>
<td>D. cineria</td>
<td>36.4</td>
<td>49.1</td>
<td>47.0</td>
</tr>
<tr>
<td>A. nilotica</td>
<td>31.5</td>
<td>49</td>
<td>38.0</td>
</tr>
<tr>
<td>L. leucocephala</td>
<td>24.0</td>
<td>47</td>
<td>24.0</td>
</tr>
<tr>
<td>A. lebbek</td>
<td>34.0</td>
<td>42.5</td>
<td>26.0</td>
</tr>
<tr>
<td>A. indica</td>
<td>53.0</td>
<td>44</td>
<td>71.4</td>
</tr>
<tr>
<td>Kheri</td>
<td>39.6</td>
<td>52</td>
<td>47.4</td>
</tr>
</tbody>
</table>
Biotype studies: To determine the race of biotype of *M. incognita* prevalent in this area soil sample of infested field was collected and filled in 15 cm pots. The international differentials for race identification have been planted.

**Table 46.** Screening of elite sections of cowpea against root-knot nematode, *M. incognito* for resistance

<table>
<thead>
<tr>
<th>Selection</th>
<th>Root-knot index</th>
<th>Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hy 5-85-9</td>
<td>3</td>
<td>S</td>
</tr>
<tr>
<td>IL 978</td>
<td>3</td>
<td>S</td>
</tr>
<tr>
<td>IL 450</td>
<td>1</td>
<td>T</td>
</tr>
<tr>
<td>IL 143</td>
<td>4</td>
<td>HS</td>
</tr>
<tr>
<td>Hy 7-87</td>
<td>3</td>
<td>S</td>
</tr>
<tr>
<td>IL 1008</td>
<td>2</td>
<td>S</td>
</tr>
<tr>
<td>Hy 5 P-5-1</td>
<td>2</td>
<td>S</td>
</tr>
<tr>
<td>IL 515</td>
<td>2</td>
<td>S</td>
</tr>
<tr>
<td>IL 985</td>
<td>4</td>
<td>HS</td>
</tr>
<tr>
<td>IL 984</td>
<td>2</td>
<td>S</td>
</tr>
<tr>
<td>C 152</td>
<td>1</td>
<td>T</td>
</tr>
</tbody>
</table>

S—Susceptible,  T—Tolerant  HS—Highly Susceptible
The Regional Station of Indian Grassland and Fodder Research Institute of Dharwad came into being from May, 1987. The station is primarily meant for the management and improvement of *Sehima* / *Dichanthium* grass cover spread in the dry sub-humid peninsular India and also aims at the management and improvement of cultivated fodder crops of the region.

Regional station's Research Farm located at Tegur, Dharwad district is 28 kms away from Dharwad towards Pune. Soils of the farm are predominantly red in colour and black soils do occur on lowlands. In most cases soil contains pebbles in an embedded state. Irrigation facilities are meagre and discharge from bore wells are poor. Average annual rainfall ranges from 800 to 1000 mm. (as per recent records) spread from June to November.

Tegur farm supports a good grassland vegetation dominated by *Heteropogon*/*Themeda*/*Cymbopogon* communities. Grasses *Sehima nervosum* and *Dichanthium annulatum* are poorly represented in these grasslands. Only the legume worth reporting is *Atylosia scarabaeoides* which is moderately spread in the grasslands of Tegur. Phytosociological studies initiated during monsoon 1987 in these grasslands shall be completed during July/August 1988. Grassland production was estimated from different grassland and associations during September 1987 and are as under:

1) *Heteropogon/Cymbopogon* — 102.5 q green/ha
2) *Cymbopogon/Heteropogon/Digitaria* — 110.0 q green/ha
3) *Sehima/Heteropogon* — 100.0 q green ha
4) *Themeda/Heteropogon* — 126.6 q green/ha
5) *Cymbopogon/Themeda/Heteropogon* — 245.6 q green/ha
6) *Pennisetum/Heteropogon/Themeda* — 134.4 q green/ha
SRS-1 : STUDIES ON SILVIPASTORAL PRACTICES FOR POOR DEGRADED RED GRAVELLY SOILS OTHERWISE DOMINATED BY HETEROPOGON GRASSLAND FOR IMPROVED PRODUCTION

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

The three combinations of silvipastoral system viz. fodder tree+fodder grass, fodder tree+fodder legume and fodder tree+fodder grass+fodder legume uniformly fertilised with 20 kg P₂O₅ and 20 kg N/ha annually were laid out at Tegur farm, during June/July 1987. Fodder tree *Leucaena leucocephala* cv. Cunnigham spaced at 1.5×1.5 m (row to row and plant to plant) raised during 1985 was used for the said study. The plants were clear felled uniformly at ground level during the 3rd week of May 1987 and the coppicing growth of plants thus obtained were main ained till 3rd week of September 1987. During September, growth attained by plant were harvested at ground level leaving one branch of one metre height to grow.

There were three sets of experiments laid out in RBD having four replications for each treatment. The plot size was limited to 3 m×3 m size enclosing therein 9 plants of *Leucaena* in rows of 1.5×1.5 m spacing. Grasses and legumes grown as intercrop in rows of 40 cm apart and mixtures of the same were raised in alternate rows of 1:1 proportion.

In the 1st set, cultivated grasses *Panicum maximum; Chloris gayana* with and without range legume *Stylosanthes hamata* cv. Verano were raised in between *Leucaena* rows.

In the 2nd set, range grasses *Cenchrus ciliaris, Chrysopogon fulvus* with and without range legume *Stylosanthes hamata* cv. Verano were raised in between *Leucaena* rows.

In the 3rd set, range grasses *Dichanthium annulatum, Chrysopogon fulvus* with and without legume *Macroptilium atropurpureum* cv. Siratro were raised in between *Leucaena* rows.

1st and 2nd sets of experiment were laid out during July and 3rd set during August. Because of delayed establishment of certain grasses and legumes in the experiments, only established grasses and legumes like *Panicum maximum, Chloris gayana, Cenchrus ciliaris* and *Stylosanthes hamata*, respectively were harvested twice in the year to record herbage production. The experimental results are tabulated in (Table-47).

Among the various silvipastoral systems tested, highest production was recorded
in treatments wherein fodder tree *Leucaena* was intercropped with guinea grass and range legume *Carribean stylo*, which yielded 357.5 q green/ha. Next highest production was recorded in fodder tree *Leucaena* intercropped with range legume *Carribean stylo* which yielded 318.3 q green/ha.

In the second set, higher production was recorded in a combination wherein *Leucaena* was grown along with Buffel grass to yield 287.1 green/ha.

From the above it can be concluded that the level of forage production varied among different silvipastoral systems. In both the sets of experiment, green forage production from fodder tree alone ranged between 161.00 to 228.33 q green/ha and a change over from monoculture of *Leucaena leucocephala* to silvipastoral system of forage farming, forage production increased and ranged between 25 to 44.88 percent. Further, the morphological attributes studied for fodder tree, grass, and range legume also varied in different silvipastoral systems studied.

**Evaluation of forage grasses and legumes**

In order to evaluate the fodder potentials of various grass/legume, a trial on germplasm evaluation was laid out during August/September 1987. Plots of the 3 x 4m numbering 57 each for grass and legume respectively were prepared and various introduction of forage species were planted/seeded during the year. Grasses viz., (1) *Cenchrus ciliaris* – twenty lines (2) *Cenchrus setigerus* – three lines (3) *Cenchrus hybrid* (4) *Dichanthium annulatum* – two lines (5) *Chrysopogon fulvus* – two lines (6) *Dichanthium caricosum* (7) *Brachiaria de cumbens* (8) Thin para (9) Red Natal (10) *Amphilobis glbra* (11) *Chloris gayana* (12) *Congo signal* (13) *Pasphalum natalum* (14) *Pasphalum dilatatum* (15) *Pennisetum fasedum* (16) *Panicum maximum* (17) *Panicum sps* (18) *Brachiari~ mutica* (19 Hybrid Napier – Fourteen lines.

Legumes viz. (1) *Stylosanthes hamata* – thirteen lines (2) *Stylosanthes scabra* (3) *Stylo­santhes viscosa* (4) *Stylosanthes guyanensis* (5) *Macroptillium atropurpureum* Cv. Siratro (6) *Clitoria ternata* (7) *Phaseolus lathyroides* (8) *Sesbania aegytiaca* (9) *Stylosia scarabaeoides* – two lines were established.

Because of late establishment of plants herbage yield was poor and hence the same is not being reported. However, seed collections of various germplasm materials were undertaken.

Pasture of *Dichanthium annulatum* with *Stylosanthes hamata* Cv. Verano (1:1 proportion) measuring about one acre, *Panicum maximum* with *Stylosanthes hamata/Macroptillium atropurpureum* measuring about 0.5 acre, *Leucaena leucocephala* (0.75 x 0.75m row to row and plant to plan) measuring about 0.5 acre, seed multiplication plots of *Chloris gayana, Stylosanthes scabra, Stylosanthes viscosa, Cenchrus ciliaris* – 10 lines were established during the year. Seed collection of *Dichanthium annulatum, Cenchrus ciliaris, Macroptillium atropurpureum, Stylosanthes hamata* Cv. Verano, *Stylosanthes scabra, Stylosanthes viscosa, Pennisetum pedicellatum, Leucaena leucocephala* were undertaken and stored for future use.

Nearly 7 acres of farm land were brought under plough, seeded with hybrid maize and harvested, mad hay and handed over to State Livestock Farm, Tegur.
Table-47: Growth attributes and herbage yield from different silvipastoral systems

<table>
<thead>
<tr>
<th>Silvipastoral System</th>
<th>Treatments</th>
<th>Green herbage yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Leucaena leucocephala</td>
<td>(a) Leucaena + Chloris</td>
<td>210.88</td>
</tr>
<tr>
<td></td>
<td>(b) Leucaena + Chloris</td>
<td>222.66</td>
</tr>
<tr>
<td></td>
<td>(c) Leucaena + S. hamata</td>
<td>228.33</td>
</tr>
<tr>
<td>2. Leucaena leucocephala</td>
<td>(a) Leucaena + Panicum</td>
<td>212.00</td>
</tr>
<tr>
<td></td>
<td>(b) Leucaena + Panicum</td>
<td>197.00</td>
</tr>
<tr>
<td></td>
<td>(c) Leucaena + S. hamata</td>
<td>228.33</td>
</tr>
<tr>
<td>3. Leucaena leucocephala</td>
<td>(a) Leucaena + Cenchrus</td>
<td>215.00</td>
</tr>
<tr>
<td></td>
<td>(b) Leucaena + S. hamata</td>
<td>161.00</td>
</tr>
<tr>
<td></td>
<td>(c) Leucaena + Cenchrus</td>
<td>209.44</td>
</tr>
</tbody>
</table>
I Research Papers Published


Roy, M. M. 1986. Seedling growth of *Albizia amara* (Roxb) Boiv. on different soil types *Indian J. Range Mgmt.* 7 (2) : 63–70.


Singh, Panjab. 1987 Research on Fodder and Grassland makes Headway. *Indian Fmg.* 36 (8) : 3-6


Srivastava, K. and S. N. Tripathi, 1987. Interspecific cross between *Atylosia albicans* × *Atylosia cajanifolia* *Cur Sci.*, (in press)


II. Papers presented to the Seminars/Workshops/Symposia during the year 1987

Ahmed, S. T. Grass rusts, their role in food and forage production. Paper presented to the National Symposium, held from November 9-12 at IGFRI, Jhansi.


Deb Roy, R. Silvopastoral production from wasteland in respect of forage, fuelwood and leaf fodder. Paper presented to the Subject Matter Workshop-Cum-Seminar on Fodder Production and Utilisation, held from 15-24 at IGFRI, Jhansi.

Deb Roy, R. Aerial biomass production and distribution of Albizia procera under silvopastoral system. Paper presented to the National Rangeland Symposium, held from Nov. 9-12 at IGFRI, Jhansi.

Deb Roy, R. Silvopastoral system for economic utilisation of wasteland. Paper presented to the training course on Social Agroforestry, held on Nov. 24 at IGFRI, Jhansi.


Hazra, C. R. **Soil and water management for increased dryland crop productivity in Bundelkhand region.** Paper presented to the National Rangeland Symposium, held from November 9–12 at IGFRI, Jhansi.


Hazra, C. R. and O. P. Singh. **Present position and progress on Tejpura Model Watershed.** Paper presented to the Science & Technology to combat drought, held on Nov. 11 at CSIR Bhawan, New Delhi.


Hazra, C. R. **Research Highlights of 1986–87 rabi coordinated trials.** Paper presented to the Group Meeting of AICRP on Forage Crops held from Sept. 7–8 at IGFRI, Jhansi.

Hazra, C. R. **Progress and Achievements of Tejpura Model Watershed Resource Research Management Project.** Paper presented to the National Workshop on ORPs on Watersheds, held from March 7–10 at Konkan Krishi Vidyapeeth, Depoli.


Kanodia, K. C. Pasture production vis-a-vis Sheep rearing—Abstr, to the Nat. Symp. Livestock Prod. vis-a-vis Fodder, Pasture Development, held from March 2-3 at Sukhadia Univ. Farm, Chandan (Raj.).

Kanodia, K. C. Potentials of grazinglands and their management strategies in India. Paper presented to the National Rangeland Symposium, held from Nov. 9-12 at IGFRI, Jhansi.


Kanodia, K. C. Pasture establishment and management technology in India. Paper presented to the training programme on Agroforestry for NDB, held from Nov. 24 to Dec. 4 at IGFRI, Jhansi.


Pachauri, V. C. Animal production on rangeland. Paper presented to the National Rangeland Symposium, held from Nov. 9–12 at IGFRI, Jhansi.


Prasad, J. Animal health problems in grazing animals. Paper presented to the National Rangelands Symposium, held from Nov. 9–12 at IGFRI, Jhansi.

Rai, P. Comparative study on the effect of fertilizers and introduction of legumes on the productivity of *Cenchrus ciliaris* Linn. Paper presented to the National Symposium on Alternate Farming Systems, held from Feb. 21–23 at IARI New Delhi.

Rai, P. Productivity of Marvel grass as influenced by intercropping with pasture legumes. Paper presented to the National Rangelands Symposium, held from Nov. 9–12 at IGFRI Jhansi.


Roy, M. M. Testing trials of seven under-utilised fodder trees/shrubs at Jhansi centre. Report presented to IV All India Co-ordinated Project Workshop on Under-utilised and under exploited plant, held from July 6–8 at CAZRI, Jodhpur.

Roy, M. M. Lopping management of selected fodder trees for lean period green fodder supply. Paper presented to the training course on Social/Agroforestry, held on Nov. 30 at IGFRI, Jhansi.


Shukla, G. P. Genotype x spacing interactions and genetic parameters for some quantitative traits in Egyptian clover. Paper presented to the Symposium on Crop Improvement, held from Feb. 23–27 at PAU, Ludhiana.

Shukla, G. P. Quantitative variability in Egyptian clover. Paper presented to the All India Seminar on Advances in Biometrical Research in India during last ten years (1975–86), held from Nov. 1–3, 1987 at Bikaner.


Singh, Panjab and J. N. Gupta. Unique life support species and their population used by local people in India under extreme environmental conditions. Paper presented to Regional Workshop on Maintenance and Evaluation of Life Support Species in the Pacific Region, held from April 4-7 at NBPGR, New Delhi.


Singh, Panjab. Grassland in Forest ecosystems – their utilization and management in India. Paper presented to the International Symposium on Grassland in Forest area held from Sept. 2–7 at Harbin, China.


Singh, R. C. Performance of pearl millet in agro-silvopastoral system under semi-arid condition of Rajasthan. Paper presented to the International Workshop on Agroforestry for rural needs, held from Feb. 22-26 at Vigyan Bhawan, New Delhi.


Tomer, P. S. Quality of oat forage in relation to nitrogen and phosphorus levels under variable crop sequences. Paper presented to the Symposium on Alternate Farming Systems, held from Feb. 21-23 at IAR1, New Delhi.

Tomer, P. S. Fuel, feed fodder and food crops in desert. Paper presented to the National Rangeland Symposium, held from November 9-12 at IGFRI, Jhansi.

Tomer, P. S. Grassland development in Watershed. Paper presented to the Workshop on Dryland Farming, held from July 13-18 at Bankers Institute for Rural Development at Lucknow.

Tripathi, S. N. Woody perennial hybrid Pigeon pea. Paper presented to the training course on Social Agroforestry for N. D. D. B., held from Nov. 24 to Dec. 4 at IGFRI, Jhansi.

Tripathi, S. N. Spontaneous chromosome aberration in Pigeon Pea (Cajanus cajan (L) Mill. spp.) Paper presented to the National Symposium on Genome Manipulation, held from Dec. 26-27 at Patna University, Patna.
Tripathi, S. N. Hybridization of *Cajanus* with *Atylosia* species. Paper presented to the National Symposium on Cytogenetical Research in India, held from Feb. 21–23 at Patna University Patna.

Tripathi, S. N. Possible gene source for improvement of Pigeon pea (*Cajanus cajan* (L.) Mill sp.) Paper presented to the National Seminar on recent trends in manipulating plant growth and development, held from Oct. 9–10 at Utkal University, Bhubaneshwar.


Tripathi, S. N. Gene exchange through hybridization in *Atylosia* spp. Paper presented to the National Rangeland Symposium, held from Nov. 9–12 at IGFRI, Jhansi.

Tripathi, S. N. Fodder production practices with reference to dry land areas (Hi). Paper presented to AFPRO sponsored training programme on Fodder for Drought Period, held from November at IGFRI, Jhansi.


Trivedi, B. K. Phytosociological structure of certain grasslands of Central India -- Jhansi. Paper presented to the National Rangeland Symposium, held from Nov. 9–12 at IGFRI, Jhansi.

Tyagi, R. K. Bharat me chara utpadan ke liye bhu upyog (Hi). Paper presented to the AFPRO sponsored training course on Fodder for Drought Periods, held from September 15–24 at IGFRI, Jhansi.


Tyagi, R. K. Grazing lands of Bundelkhand, their present status and future strategies
for improvement. Paper presented to the National Rangeland Symposium, held from November 9–12 at IGFRI, Jhansi.


Yadav, I. P. S. Factors affecting growth and instability of food and fodder production system. Paper presented to the National Symposium on Growth and Instability in Agriculture, held at IARI, New Delhi.

Yadav, R. B. R. Efficacy of Plant growth regulators in forage seed production. Paper presented to the conference on Plant Physiology SAARC.
III Bulletins


IV Reports

IGFRI–Activities and Achievements, IGFRI, Jhansi.
IGFRI–25 Years of Research, IGFRI, Jhansi, 135 p.
Souvenir. IGFRI, Jhansi, 60 p.

V. Extension Literature


Singh O. P. and Maharaj Singh. Nali evom Mend banane wale Unnat Krishi Yantra (Hi),


AWARDS RECOGNITION AND VISITS ABROAD

Awards

The work done by the Institute in association with the State Agril. Departments in Tejpu"r Watershed have won the KRIBHCO Award for Outstanding Research in Dryland area and also National Productivity Award for the year 1986–87. The two awards were presented by the Union State Minister for Agriculture and the Hon'ble President of India, respectively in the functions organised in New Delhi.

Visit Abroad

1. Dr. Panjab Singh, Director attended the International Symposium on Grassland in Forest Area held at Harbin, China from 2–7 September 1987.

2. Dr. P. S. Pathak, Head ASP Division and Dr. R. Deb Roy, Senior Scientist, ASP Division attended the International Training course on "Farm Forestry" in China from 1–30 May 1987.

3. Dr. R. C. Singh, Scientist S-2, ASP Division attended the research discussion on "Agro-forestry" at ICRAF Nairobi (Kenya) from 6–16 Dec. 1987.

4. Dr. A.S. Gill, Sr. Scientist has been deputed as a team leader on Forage Production in Vietnam.
SILVER JUBILEE CELEBRATIONS

The Indian Grassland and Fodder Research Institute organised year long celebrations to commemorate its Silver Jubilee. The celebrations were opened by Dr. (Mrs.) Kamala Chaudhary, Chairman, National Wastelands Development Board in November 1986. This function was presided by Dr. M. V. Rao, Special Director General, ICAR. The National Seminar-cum-Training on Silvipastoral System—the land use for Wastelands was also organised in November, 86 in which 49 delegates participated from 10 states. This Seminar was supported by IDRC under the Silvipastoral Operational Research Project functioning at the institute.

Dr. G.S. Dhillon, Hon'ble Union Minister of Agriculture inaugurated the Agronomy Field Laboratory during June 1987 and declared to establish a National Research Centre on Agro-Forestry at Jhan: Hon'ble Minister of Agriculture, U. P. State, Shri Narendra Singh presided over the function. Dr. N. S. Randhawa, Director General, ICAR and Secretary to the Government of India and Dr. M. V. Rao, Special Director General, ICAR also graced this function.

During August, 1987 the massive plantations programme was inaugurated by Dr. Panjab Singh, Director of the Institute. The plantations included the hortipastoral, avenue, shed trees and shelter belt plants.

On September 21, 1987 the Western Regional Station of the Institute at Avikanagar was formally inaugurated by the Hon’ble Union State Minister of Agriculture, Shri Yogendra Makwana. The Hon’ble Animal Husbandry Minister of Govt. of Rajasthan was also present among the other distinguished guests.

The series of lectures on Forage Production and Utilization were broadcasted from All India Radio, Lucknow and Chhatarpur. The special issues of Indian Farming and Kheti were brought out by the Publication Division of Indian Council of Agricultural Research. During the year, publication programme was geared up and 14 publications comprising of reports, bulletins, special lectures, etc. and 6 extension leaflets were published. This included “IGFRI 25 years of research” and Souvenir on Silver Jubilee.
The Silver Jubilee Sports were organised for the staff as well as their family members under the aegis of Recreation Club, IGFRI. Similarly, three cultural programmes and a programme on ‘Yoga’ were organised.

The concluding function was organised from November 9–14, 1987. This programme had various components viz., National Rangeland Symposium, All India Kisan Mela, All India Exhibition, series of Memorial Lectures, etc.

The National Rangeland Symposium was organised from November 9–12, 1987 at Indian Grassland and Fodder Research Institute, Jhansi. It was organised jointly by the Range Management Society of India and IGFRI, Jhansi and was sponsored by Indian Council of Agricultural Research, NABARD, Indian Dairy Corporation, Tata Energy Res. Institute, Council of Scientific and Industrial Research, Society of Development Alternatives and Baidyanath Ayurveda Bhavan.

The Symposium was inaugurated by Sri Hukum Singh, Hon’ble Minister for Animal Husbandry, Govt. of U. P. and chaired by Dr. M. V. Rao, Special Director General, ICAR. Dr. Panjab Singh Director, IGFRI and President of the Society introduced the subject. Prof. S. C. Pandeya, President, 3IRC gave perspectives of the Rangelands and our role in solving their problems. Out of over 150 scientists who responded to our first circular, 100 delegates could attend the symposium. The symposium was also attended by the representatives from various International organisations viz., Ford Foundation, UNDP, IDRC, FAO, etc.

In his inaugural address the Chief Guest emphasised the need for integration of forestry and animal husbandry, adoption of villages and short and long term strategies for grazing lands. The Chairman gave his address emphasizing the need for improved variety of seeds and their multiplication, fodder bank and research priorities on rangelands.

The presentations during the symposium were organised into 22 sessions including the poster presentation, inaugural, plenary, special sessions and field trip. In these sessions over 70 papers were presented of which 59 were oral, 2 popular lectures and 6 poster presentation. Besides these, there was a group meeting on Himalayan Rangelands and a panel discussion on Fodder Trees. The Symposium was addressed to the problems of Resource Conservation and Ecology, Range Ecology, Range Management, Plant Improvement, Range Phisiology and Pathology, Himalayan Rangelands, Secondary Productivity on Rangelands Management of Marginal lands, Forestry and Agroforestry, Marginal Agricultural, Watershed Management and Development, Socio-economic aspects, Resource use for Forest and Fuel etc.

This symposium had a special feature incorporating the three memorial lectures delivered in the memory of Late Sri P. M. Dibadghao, Dr. M. L. Migoan and Dr. K. A. Shankarnarayan by eminent scholars in the evenings of 9th, 10th and 11th November.
Based on the deliberations several recommendations have been made to improve the scientific know how of these ecosystems and to provide management principles to improve production.

All India Kisan Mela was organised from November 7-10, 1987 in which large number of farmers from 9 States viz. Uttar Pradesh, Madhya Pradesh, Arunachal Pradesh, Tripura, Andhra Pradesh, Tamil Nadu, Karnataka, Haryana and Sikkim participated. This was inaugurated by Hon'ble Minister of Agriculture Govt. of U. P., Shri Narendra Singh and presided by Dr. N. S. Randhawa, Director General, ICAR and Secretary to the Govt. of India, Dr. C. Prasad, DDG (Extn.) addressed the farmers. The magnificent pavillons were put by various research institutes and Govt. departments.

In the concluding function held on 14th November, 1987 prizes were given away by Sri S. S. Dawara, Secretary, ICAR, New Delhi.
APPENDIX-I

LIST OF STAFF

( as on 31st December, 1987)

Director: Dr. Panjab Singh Ph. D.

1 Scientific:

Division of Plant Improvement

Bhagmal, Ph. D., S-3 (Plant Breeding) & Head of Division (upto 31-1-87)
S. R. Gupta, Ph. D., S-3 (Economic Botany) & Head of Division (w. e. f. 1-2-87)
C. B. Singh M. Sc., S-2 (Plant Breeding)
Devendra Singh, M. Sc. S-2 (Plant Breeding)
S. N. Zadoo, Ph. D. S-2 (Genetics & Cytogenetics)
S. N. Tripathi, Ph. D., S-2 (Genetics & Cytogenetics)
S. K. Gupta, Ph. D., S-2 (Plant Breeding)
R. N. Choubey, Ph. D., S-2 (Plant Breeding)
G. P. Shukla, Ph. D., S-2 (Plant Breeding)
M. G. Gupta, Ph. D., S-2 (Genetics & Cytogenetics)
K. S. Kohli, Ph. D., S-1 (Plant Breeding)
J. N. Gupta, Ph. D. S-1 (Economic Botany)
U. P. Singh, M. Sc., S-1 (Economic Botany)
U. S. Misra, M. Sc., S-1 (Plant Breeding)
D. N. Singh., Ph. D., S-1 (Plant Breeding)
M. N. Premachandran, M. Sc. S-1 (Genetics & Cytogenetics)
Dr. Malaviya, Ph. D. S-1 (Plant Breeding)
Division of Agronomy

Menhi Lal, Ph. D. S-3 (Agronomy) & Head of Division
A. S. Gill, Ph. D., S-3 (Agronomy)
N. P. Shukla, Ph. D., S-2 (Agronomy)
S. N. Tripathi, M. Sc., S-2 (Agronomy)
Bhoori Singh, Ph. D., S-2 (Agronomy)
M. S. Raut, M. Sc., S-1 (Agronomy) (up to 3-8-87)
K. S. Gangwar, Ph. D., S-1 (Agronomy)
S. D. Gupta, M. Sc., S-0 (Agronomy)

Division of Grassland Management

K. C. Kanodia, Ph. D., S-4 (Economic Botany) & Head of Division (up to 10-8-87)
P. Rai, Ph. D., S-2 (Agronomy) & Head of Division (w. e. f. 11-8-87)
Vinod Shanker, Ph. D., S-2 (Economic Botany) (w. e. f. 15- 6-87)
P. K. Jayan, Ph. D., S-2 (Economic Botany) (upto 20-3-87)
B. K. Trivedi, Ph. D., S-2 (Economic Botany)
S. S. Parihar, M. Sc., S-1 (Economic Botany)
K. P. Niranjan, M. Sc. S-1 (Agronomy)

Division of Agro-Silvipasture

P. S. Pathak, Ph. D. S-3 (Economic Botany) & Head of Division
R. Deb Roy, Ph. D., S-4 (Economic Botany)
V. K. Gupta Ph. D., S-2 (Plant Breeding)
R. C. Singh M. Sc., S-2 (Agronomy)
M. M. Roy, M. Sc., S-1 (Economic Botany)
S. K. Gupta, M. Sc. S-1 (Economic Botany)
T. A. Khan, M. Sc., S-1 (Statistics)
S. K. Sharma, Ph. D., S-1 (Horticulture)
Punit Mohan, M. Sc., S-1 (upto 31-5-87)

Division of Soil Science

R. K. Tyagi, Ph. D., S-2 (Geography) & Head of Division
Dashrath Singh, Ph. D., S-2. (Soil Science)
M. R. Pahwa, Ph. D., S-2 (Microbiology)
O. P. S. Panwar, M.Sc., S-2 (Soil Science)
S. B. Tripathi, M. Sc., S-1 (Soil Science)
I. Y. L. N. Murthy, M. Sc., S-1, (Agricultural Chemistry)
Pradeep Behari, M. Sc., S-1 (Physics)
P. B. N. Murthy, M. Sc., S-1 (Soil Science)
Raj Bahadur Yadav, M. Sc., S-1 (Soil Science)

Division of Plant Animal Relationship

V. C. Pachauri, Ph. D., S-3 (Animal Nutrition) & Head of Division
A. Rekib, Ph. D., S-4 (Animal Nutrition)
R. K. Gupta, Ph. D., S-4 (Organic Chemistry)
P. Kumar, Ph. D., S-3 (Animal Nutrition)
A. P. Singh, Ph. D., S-3 (Agricultural Chemistry)
S. C. Gupta, M. Sc., S-2 (Analytical Chemistry)
V. S. Upadhyay, M. Sc., S-2 (LPM)
J. P. Varshney, M. Sc., S-2 (Veterinary Medicine)
N. C. Verma, M. Sc., S-2 (LPM)
A. B. Mojumdar, M. Sc., S-2 (Biochemistry)
L. K. Karnani, M. Sc., S-1 (Agricultural Chemistry)
J. N. Sebastier, M. Sc., S-1 (Organic Chemistry)
B. K. Bhadoria, M. Sc., S-1 (Organic Chemistry)

Division of Seed Technology

P S. Tomer, Ph. D., S-4 (Agronomy) & Head of Division
R. P. Singh, Ph. D., S-4 (Agronomy) (upto 7-8-87)
R. K. Pandey, Ph. D. S-3 (Agronomy)
S. N. Singh, Ph. D., S-2 (Plant Pathology)
O. P. Dixit, M. Sc., S-1 (Plant Breeding)
G. K. Dwivedi, M. Sc., S-1 (Agronomy)
K. P. Singh, M Sc., S-1 (Genetics)
V. J. Shivankar, Ph. D., S-1 (Entomology)
S. M. Mishra, M. Sc., S-1 (Soil Science)

Division of Plant Physiology and Biochemistry

R. B. R. Yadav, Ph. D., S-3 (Plant Physiology) & Head of Division
L. P. Mishra, Ph. D., S-3 (Plant Physiology) (w. e. f. 12-10-87)
N. C. Sinha, Ph. D., S-2 (Plant Physiology)
R. K. Bhatt, M. Sc., S-1 (Plant Physiology)

Division of Plant Protection

S. T. Ahmed, Ph. D., S-2 (Plant Pathology) & Head of Division
S. A. Faruqui, Ph. D., S-2 (Entomology)
K. C. Pandey, M. Sc., S-2 (Entomology)
W. L. Barwad, M. Sc., S-2 (Entomology)
M. I. Azmi, Ph. D., S-2 (Nematology)
R. K. Jain, Ph. D., S 2 (Nematology) (upto 3-7-87)
N. Hasan, Ph. D., S-2 (Nematology)
R. B. Bhaskar, M. Sc., S-1 (Plant Pathology)

Division of Agricultural Engineering

Jai Singh, Ph. D., S-4 (Agriculture St. & Proc. Engg.) & Head of Division
R. B. Varshney, B. Tech., S-1 (Soil Water Engg.)
J. M. Scod, M. Tech., S-1 (Soil Water Engg.)
P. S. Chattopadhyay, M. Tech. (FMP)

Division of Rural Economics and Biometrics

I. P. S. Yadav, M. Sc., S-2 (Agric. Economics) & Head of Division
P. R. Sreenath M. A. Dip. (Agriculture Stat) S-3 (Stat.) (upto 21-4-87)
Mallaya M. A., S-1 (Economics)
Ram Ashrey Singh, M. A. S-1 (Economics)
Ashok Kumar, M. Sc., S-1 (Statistics)
Division of Extension and Training

O. P. Singh, Ph. D., S-2 (Agronomy) & Head of Division (w. e. f. 1-8-1987)
M. R. Lokhande, Ph. D., S-3 (Agric. Exten.) & Head of Division (upto 31-7-1987)
Maharaj Singh, M. Sc., S-1 (Extens on)
Mahavir Singh, M. Sc., S 0 (Agric. Extn.)

Forage Project

C. R. Hazra, Ph. D., S-3 (Project Coordinator)
C. R. Rawat M. Sc., S-2 (Agronomy)
Khubi Singh, M. Sc., S-1 (Statistics)

Dryland Project

O. P. Singh, Ph. D., S-2 (Agronomy)

Regional Station, Srinagar (J & K)

B. K. Misri, Ph. D., S-2 (Economic Botany) & I/C Station

Regional Station, Avikanagar (Rajasthan)

Fateb Singh, M. Sc., S-2 (Agronomy) I/C Station
R. K. Jain, Ph. D., S-2 (Nematology) (w. e. f. 4-7-87)

Regional Station, Dharwar (Karnataka)

P. K. Jayan, Ph. D., S-2 (Economic Botany) & I/C Station (w. e. f. 21-3-87)
M. S. Raut, M. Sc., S-1 (Agronomy) (w. e. f. 4-8-87)

II. Technical

A. K. Srivastava, Technical Officer (T-6)
M. M. Rastogi, Assistant Librarian (T-5)
C. B. Mishra, Photographer-cum-Artist (T-5)
N. C. Srivas, Lab. Assistant (T-5)
H. B. Dhingra, Land Surveyor (T-5)
S. K. Rajpali, Sr. Technical Assistant (T-5)
M. S. Sharma, Farm Superintendent (T-5) (w. e. f. 27-4-87)
R. B. Mathur (T-4)
D. K. Bhutani (T-4)
Shree Ram Sikanya (T-4)
C. P. Gupta (T-4)
Mahi Pal Singh (T-4)
Ravindra Pal Singh (T-4)
Pramod Kumar Dwivedi (T-4)
Gyasi Lal (T-4)

III. Administrative

A. Ramdas, Account Officer
H. C. Saxena, Administrative Officer
L. S. Sharma, Asstt. Adm. Officer
Gauri Shanker, Asstt. Adm. Officer
O. P. Dubey, P. A. to Director
Subhash Chandra, Superintendent (w. e. f. 31-1-87)
Ram Baboo Sharma, Superintendent (w. e. f. 31-3-87)
Veer Singh, Superintendent
S. N. Dubey, Superintendent
K. R Shashi, Superintendent

IV. Auxilliary

V. K. Litoria Medical Officer
Statement showing head-wise expenditure during 1987-88

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<th>NON-PLAN (in Rs.)</th>
<th>PLAN (in Rs.)</th>
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<td>1. Pay &amp; Allowances</td>
<td>1,00,16,965.65</td>
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<td>3. Recurring Contingencies</td>
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<td>4. Non-recurring Contingencies</td>
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<td>1) Works</td>
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<td>2) Equipments</td>
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<td>4) Others</td>
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