वार्षिक प्रतिवेदन
Annual Report
1997-98

OPEN

IGFRI

भारतीय चरागाह एवं चारा अनुसंधान संस्थान
Indian Grassland and Fodder Research Institute

वार्षिक प्रतिवेदन

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भारतीय चरागाह एवं चारा अनुसंधान संस्थान, झाँसी
Indian Grassland and Fodder Research Institute, Jhansi-284003

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Published	:	March, 1998

Printed at Mini Printers, Jhansi. Ph. 446820

PREFACE

The Indian Grassland and Fodder Research Institute has the national mandate to conduct and coordinate the basic, applied and strategic research on all aspects of forage production and utilization. The year 1997-98 was marked by several important milestones resulting in more output oriented programmes. Two varieties, one each in berseem (Bundel Berseem-2) and Oat (Bundel Jai-2) have been released. The production technologies were identified. For strengthening the transfer of technology programmes, the technologies on the shelf were identified. The efforts were made to consolidate the physical resources to provide strong base for multidisciplinary mission oriented research programme. Three new units, *viz*., Consultancy Cell, PRA Cell and HRD unit have been created.

In the context of fast changing global scenario, Institute formulated a Perspective Plan envisaging visionary approach up to 2020 AD.

The training component was further strengthened. FAO has recognized the IGFRI as its training centre and International Training Programme on Management and Utilization of Fodder Trees/Shrubs in Sub-tropical and Temperate Himalaya.

A good progress has been made in the field of International Linkages. The MTR mission appreciated the progress of Indo-UK Project during last 3 years. The Indo-Australian project has been finalized. Similarly ICRA, The Netherlands has agreed to have joint field study with IGFRI.

The Annual Report encompasses the various activities and research progress made this year in different disciplines. I acknowledge the contributions and efforts of Heads of Divisions/Units/Regional Centres and Technical Information Committee in bringing out this Report.

(Bhg Mal)
Director

1. EXECUTIVE SUMMARY

During the year 1997-98, IGFRI has made rapid strides in research work on forage production and utilization. The significant findings are as below :

CROP IMPROVEMENT

Plant Genetic Resources

Genetic diversity was enriched by conducting two explorations (Bundelkhand districts of UP and MP and Central districts of Rajasthan) and through correspondence from ILRI, Ethiopia. 635 accessions of range grasses/cereals and 643 accessions of range/cultivated legumes were added to genetic stock.

Plant Breeding

One variety each in berseem (Bundel Berseem-2) and oat (Bundel Jai-2) have been released by Central Varietal Release Committee on the basis of their superiority in forage yield and quality.

In final evaluation trial of cowpea, Institute entry IFC-9503 gave the maximum green fodder yield (30 t/ha). The other entry IFC-9502 (27.5 t/ha) also proved better (24.8 t/ha) than check (Bundel Lobia-1).

IGFRI entries JHTB 96-4 and JHTB 96-5 of tetraploid berseem were ranked first and second respectively in all India coordinated trial and two new diploid (JHB 97-1, JHB 97-2) and two tetraploid JHTB 97-3 and JHTB 97-4 lines were entered in the trial.

In All India Coordinated Trial, IGFRI Lablab bean entries LP-27 and LPS-2 proved superior over control (Bundel Sem-1) by a margin of over 11.0 and 9.0%, respectively.

Cenchrus entries IGFRI-3133, 675 and 8-4-3 showed good performance for both green and dry fodder yield in All India Coordinated Trial.

Clitoria ternatea lines IGFRI-23-1 (GFY 21.2 t/ha, DFY 4.58 t/ha), IGFRI 173-1 (GFY 20.56 t/ha, DFY 4.44 t/ha) and IGFRI 7-3 (GFY 19.43 t/ha, DFY 4.25 t/ha) were found superior over other entries in all India coordinated trial.

Genetics and Cytogenetics

In oats, a number of lines having chromosomal stability at A_{12} generation derived from *Avena sativa* x *A. maroccana* registered superiority over the check in terms of forage yield under multicut.

Similarity index worked out through isozyme analysis established that *Pennisetum glaucum* is closely related with *P. violaceum* followed by *P. squamulatum* and *P. purpureum*.

Auxin induced parthenocarpy test and pistil-clearing technique revealed the *Cenchrus prieurii* as completely sexual and the *Cenchrus* hybrid plant and two accessions of *C. ciliaris* as facultative apomicts. In *C. echinatus* pistil clearing technique revealed its complete sexuality.

Plant Protection

Epidemic development of anthracnose in sorghum was recorded at its peak during mid to end of August. Among the five neem based products, 2% Neem Seed Kernel Extract (NSKE) gave the maximum reduction of 90 and 70% spore germination and mycellial growth, respectively.

In cowpea VAM fungi applied together with Neem cake proved potential biocontrol agent for root rot disease complex and also helped in nutrient uptake. Lines IFC 9702 and CL 373 were found resistant against key nematode species *Meloidogyne incognita* and *M. javanica*.

The rate of dissipation of endosulfan residue followed first order kinetics. The half life of residue and safe waiting period were found to be 4 and 14 days, respectively.

In cowpea + sorghum - berseem + Japan sarson the combination of soil treatment with Neem cake followed by seed treatment with carbofuran + bavistin + thiram produced highest average green fodder yield of 187.61 t/ha/year which is 18% higher over control (untreated).

Plant Physiology and Biochemistry

Hydrated-dehydrated seeds of sorghum (HC-136), dry dressed with calcium hypochlorite for one hour recorded lowest solute leakage (36.2%) and lipid peroxidation (24.5 µ mole per axis). Treated seeds recorded 100% seedling emergence against 96% in control.

In cowpea, minimum solute leakage (36.84%) and lipid peroxidation with maximum seedling emergence (100%) were recorded in seeds invigorated with potassium iodide for two hours.

Biotechnology

In *Medicago, in vitro* regeneration was achieved using various explants *viz.,* petiole, hypocotyl, cotyledons, node, leaf and the seeds on MS and SH media.

Somaclones of *Dichanthium annulatum* exhibited a wide array of variation and somaclones SV-27, SV-2, SV-20 and SV-7 were found to be superior over check variety Marvel-8.

Multiple shoot buds induction was achieved in *Anogeissus pendula* and leucaena hybrid (*L. diversifolia* x *L. leucocephala*) by micropropagation through auxiliary and apical shoot buds.

CROP PRODUCTION

Forage Production System under Irrigated Conditions

Guinea grass + cowpea - berseem sequence gave maximum berseem equivalent yield (108.5 t ha^{-1}). Berseem proved most productive crop followed by wheat and guinea grass. Crop fertilized with inorganic source of nutrition produced significantly higher berseem equivalent yield of 93.8 t ha^{-1}.

Plots fertilized with 100% organic source of nutrient improved soil fertility in terms of available N (206 kg ha^{-1}), P (12.08 kg ha^{-1}), K (204.5 kg ha^{-1}), S (17.8 ppm) and Organic Carbon (0.31%) as compared to that applied through 50% organic and

50% inorganic sources as well as 100% inorganic source.

Sorghum variety HD-15 produced significantly higher green and dry forage (40.0 and 7.7 t ha^{-1}, respectively) which was 13.8% higher over JS-10 and 28.5% higher over check i.e. HC-171. Crops sown in the beginning of July produced significantly higher green and dry forage yields (45.7 and 9.0 t ha^{-1}, respectively) over other dates of sowing. The yields obtained by application of 120 kg and 80 kg N ha^{-1} were almost equal.

Green and dry matter yields of hybrid napier obtained under one cut produced maximum (32.4 t green and 6.26 t dry matter ha^{-1}) which was significantly superior to guinea grass (29.7 t green and 5.60 t dry matter ha^{-1}) and setaria (23.8 t green and 4.76 t dry matter ha^{-1}).

Yield of sorghum pure and sorghum + cowpea increased with increasing levels of S application up to 60 kg ha^{-1}, the magnitude of increase being more in low S soils. The responses to added S over control (no S) in low, medium and high S soils were 14, 8 & 6 per cent for green and 15, 11 & 8 per cent for dry fodder of sorghum + cowpea as well as 11, 6 & 4 per cent for green and 11, 8 & 5 per cent for dry fodder of sorghum pure, respectively.

Maximum green fodder and dry matter yields (64.4 and 12.8 t ha^{-1} , respectively) were obtained under 100% of recommended fertilizer schedule (90:40:30 of N:P:K) in HC-136 variety of sorghum. Similar trend was also obtained for increasing levels of vermicompost upto 7.5 t ha^{-1}.

Sorghum productivity was significantly influenced by application of nitrogenous fertilizer and *Azotobacter* inoculation. Green fodder and dry matter yields increased up to 112.5 kg N ha^{-1}. The green fodder yields obtained were 28.0 and 30.6 t ha^{-1} under uninoculated and inoculated treatments of *Azotobacter,* respectively.

The perennial lucerne should be irrigated at 0.75 IW/CPE ratio adopting cutting interval of 35 days and fertilized with 60 kg K_2O ha^{-1} for higher tonnage and longer persistency.

Forage Production Systems under Rainfed Conditions

Under *Sesbania* alleys, the green forage yield of maize and cowpea was 26.4 and 21.7 t ha^{-1}, and that of dry forage 7.8 and 4.4 t ha^{-1}, respectively. The seasonal profile (0-60 cm) soil moisture depletion was relatively higher under maize as compared to cowpea. The water requirement of maize (447 mm) was higher than cowpea (415 mm).

Significantly higher green fodder (15.2 t ha^{-1}) and dry matter (3.3 t ha^{-1}) yields were obtained with pure crop of *Dolichos* as compared to cowpea + castor cropping system, followed by cowpea (pure), Dolichos + castor and cowpea + castor systems. Among the soil moisture retentive measures, ridge and furrow sowing gave maximum green fodder (14.1 t ha^{-1}) and dry matter yields (2.9 t ha^{-1}) than flat sowing. Application of fertilizer (50% each of inorganic and organic source) produced significantly higher green fodder (13.7 t ha^{-1}) and dry matter (2.8 t ha^{-1}) over 100% inorganic sources.

Sorghum (sole) gave maximum green

forage (51.25 t ha^{-1}) and dry matter (12.81 t ha^{-1}) yields followed by sorghum + cowpea (40.6 + 12.0 t ha^{-1}) green and (10.15 + 2.42 t ha^{-1}) dry matter. Among the moisture conservation techniques, jalshakti @ 5 kg ha^{-1} produced maximum green forage (45.0 t ha^{-1}) and dry matter yields (11.25 t ha^{-1}) followed by three ploughing with desi plough and planking every time (green forage 43.0 t ha^{-1}, dry matter 10.85 t ha^{-1}).

In *pennisetum* trispecific hybrid + *Stylosanthes hamata*, the highest green forage (13.7 t ha^{-1}) and dry matter yields (4.5 t ha^{-1}) were obtained with the application of 90 kg N + 60 kg P_2O_5 ha^{-1}.

Among the strains tried, inoculation of native strains (JSR-3, JSR-4 and JSB-4) produced 45-51% higher green forage biomass over exotic strains (23.6-37.3%). Stylo inoculated with native strains showed greater stimulating effect on the forage yields (+39-43%) of associated Dichanthium grass with improvement in nitrogen content (Mean value - 1.1%) as well as its uptake (78.1 mg/pot) by grass.

The results of simultaneous field study on *C. ciliaris* + *S. hamata* pasture combination also showed the similar results as strain JSR-4 gave maximum forage yield (green forage 6.0 t ha^{-1}, dry matter-2.4 t ha^{-1}). Maximum nodulation (60/plant), root length (28.6 cm $plant^{-1}$) and strain occupancy (100%) in nodules was also noticed with strain JSR-4.

Forage Production under Problem Soils

In saline - sodic soils, maximum survival of *Leptochloa fusca* (97%) was recorded which was followed by *Brachiaria mutica* (96%), *Setaria sphacelata* (84%) *Chloris gayana* (80%), *Sorghum sudanesis* (54%) and *Panicum maximum* (51%).

Under waterlogged conditions, significantly higher green fodder (10.0 t ha^{-1}) and dry matter (3.2 t ha^{-1}) yields were obtained in almen grass as compared to para grass (7.2 t ha^{-1} green fodder and 2.1 t ha^{-1} dry matter yield).

Agroclimatological Approaches

Weekly water balance model was computed for the period 1970-97 for '*mar'* soil of Bundelkhand region which shows that the crop growing season has decreased by one week in recent decade compared to previous decades.

During 170 days of crop growth period in berseem cv. Wardan, 758.0 mm cumulative evapotranspiration was recorded which gave mean value of evapotranspiration as 4.8 mm/day. The mean water use efficiency was 24.1 kg dm/ha/mm for lysimeter.

In *kharif* , maize + cowpea in paired row during 68 days of crop growth period ET for 56 days was recorded 6.7 mm/day. The total ET for combined crop growth period was 455.6 mm. The water use efficiency for mixed cropping was 15.4 kg dm/ha/mm for lysimeter.

GRASSLAND AND SILVOPASTURES MANAGEMENT

Among 14 provenances of 5 *Leucaena* species, *L. collinsii* showed best growth performance in the germplasm evaluation trial.

The Sisam *(Dalbergia sissoo*) based silvopasture produced higher forage yield as compared to *Albizia* and *Prosopis* based pasture at Ambabai revegetation site. With the participation of local villagers, Buffel grass-Carribean stylo pasture, in 2 ha, was raised at this site.

Highest survival of Pakar (*Ficus rumphii*) followed by Babul (*Acacia nilotica*) was observed at CIRG ravine revegetation site. Growth of Buffel grass was better than Dinanath grass.

In the second year of the study on management of shrub infested grassland through mixed herd grazing, marked impact on reduction of shrub volume was noticed in the treatment wherein the double stocking rate was applied. Tall shrubs beyond the reach of small ruminants particularly goats did not show impact of stocking rates.

In the first year of the study on effect of planting pattern and harvest frequencies on legume performance in mixed pasture, planting of grasses and legumes in 1:2 ratio at 50 cm and 70 days harvest frequency resulted in significantly higher forage yield of both grasses and legumes.

Grass-legume mixture demonstrated yield advantages with the application of K as relative yield total (RYT) increased with increasing K levels.

In the second year of biophysical spreadsheet modelling of silvopastoral systems, it was noticed that below ground factors (including tree roots) play an important role in the understorey grass production.

In the second year of the study on the productivity and patterns of nutrients turn over, higher level of nutrients *viz*., nitrogen, phosphorus, potassium and calcium were found in the above ground parts as compared to the below ground parts of grasses. In trees, highest nutrients were found in leafy parts followed by roots, branches and bole.

Highest average annual litter production was recorded in the 24 year old *Albizia amara* plantation (6.6 t/DM/ha) followed closely by *Hardwickia binata* plantation (6.4 t/DM/ha) of the same age.

In Ber and Kinnow based hortipastoral systems the maximum fodder production was obtained when grass (*Buffel/Sehima*) and Carribean stylo were grown as mixed crop with ber/kinnow as compared to sole crops.

In the second year of Aonla based hortipastoral system, maximum plant height and collar diameter of Aonla were observed in Aonla alone and Aonla + Marvel grass + 75 kg N/ha treatments, respectively.

PLANT ANIMAL RELATIONSHIP

The evaluation of native shrubs, *Grewia flavescens, Gymnosporia spinosa, Flacourtia inndica, Helicteres isora, Ehretia aspera, Bauhinia racemosa* and *Securinega virosa* for tannins revealed that all the shrubs could be used as fodder round the year except *B. racemosa* and *G. spinosa* during January which were found to contain more than 5% tannin during this month.

Neither fibre levels nor quality had any

impact on milk yield and the availability of macro minerals in crossbred cows. Digestible DM and NDF (estimated by incubating feed sample in the rumen for 10 days) of diet can be used as marker to determine the intake and digestibility of nutrients in grazing ruminants.

Goats relished more *Malia azadirach* leaves as compared to sheep. DM intake per cent of body wt. was 2.33 and 1.97 kg in goat and sheep, respectively without affecting the digestibility of nutrients. Serum creatine kinase activity was higher in goat (64.52 I.U./L.) than sheep (57.75 I.U./L.).

Feeding of low grain concentrate mixtures as varying source of protein (groundnut cake and mustard cake) to crossbred calves maintained on forage based rations did not have any adverse effect on growth, nutrient utilization and blood metabolites. Average daily weight gain tended to be lower in mustard cake fed groups. Thus, a lot of grains can be saved by utilizing cereal by-products as replacement of grains in concentrate mixtures of livestock.

Ammoniated grass (4% urea, 40% moisture) improved digestibility of dry matter from 55.26 to 60.80%. Live weight gain was also higher in treated grass in buffalo heifers.

SEED TECHNOLOGY

Seed Production

In *Clitoria ternatea* application of Potassium nitrate @ 2 kg and 4 kg/ha improved the seed yield (453.76 to 508.44 kg/ha) over the control (355.91 kg/ha). Foliar application of $CuSO_4$ @ 1.0 kg/ha increased the seed yield (492.56 kg/ha) over the control (420.07 kg/ha).

In *Setaria sphacelata* seed yield to the tune of (37.53 kg and 38.23 kg/ha) were found with the application of 80 kg N and 120 kg N/ha respectively.

Highest seed yield of berseem (474 kg ha^{-1}) was observed when last fodder cut was taken in March, and irrigation were given at 7 days after last cut. Tresol (a combination of macronutrients & GA) increased the seed productivity of berseem.

Seed Physiology, Seed Testing and Quality Control

In cowpea (*Vigna unguiculata*), the genotype IGFRI 450 (66 days) flowered earlier than EC 4216 (70 days) and IFC 901 (83 days). Both the genotypes EC 4216 and IGFRI 450 attained physiological maturity at 20 days after anthesis (DAA) and IFC 901 at 26 DAA. Maximum germinability coincided with maximum dry weight accumulation i.e., EC 4216 (83.3%, 7.84 g); IGFRI 450 (86.66%, 8.13 g) and IFC 901 (73.33%, 7.26 g).

In guar (*Cyamopsis tetragoroloba*), both the genotypes BG-1 and BG-2 attained 50 per cent flowering (74 days) earlier than IGFRI-1019 (79 days).

In *Stylosanthes hamata* maximum seed germination was achieved with the treatment of dilute H_2SO_4 for one minute and hot water (60°C) for one hour. The combined spray of all the chemicals i.e., 10 ppm NAA+2 kg/ha DAP + @kg/ha K has improved the growth and biomass production.

Seed Health and Storage

It was noticed for seed health that 1 % and 10% infection levels of seed resulted in 12-24% infected seedlings under controlled conditions.

Among different containers, closed plastic jars/polythene bags (700 gauge) proved to be effective against insects and pathogens infestation in leguminous seeds up to 22 months of storage and maintained their germination up to certification levels. Seeds of *Albizia lebbeck* and *Clitoria ternatea* stored in plastic jars and polythelene bags (700 gauge) with seed dressing of Bavistin and Malathion (1:1) @ 1 g/kg or *Croton tiglium* and *Acorus calamus* extracts @ 1.0 ml/kg seed controlled insect pests and storage fungi, while retaining viability up to 22 months.

Botanicals proved the efficacy of *Croton tiglium* coat (extract @ 1.0 ml/kg) seed of replacing pesticides for the storage of leguminous seeds.

FARM MACHINERY & PHT

The demonstration of improved bullock drawn farm implements was done on fodder sorghum and green grass crops in *kharif* in Karari and Lakara villages and on pea and gram in *rabi* in Karari and Sujwaha villages. The benefit of improved package over traditional method ranged from 11-23%.

The modification in base diameter of hole was done in Animal feed pelleting machine to improve its performance. The forage densifying machine was also modified to reduce the lateral vibrations.

SOCIAL SCIENCES

The study on forage based farming systems conducted in Sakrar and Awas villages indicated increase in food grains, cash crops and fodder production in the current year over the base year (1993).

The cost of fodder production was highest in cut and carry system (Rs. 0.12/kg) and was lowest in continuous grazing system (Rs. 0.05/kg), however highest fodder production was in the deferred rotational system. This deferred rotational system was most profitable followed by rotational, continuous and cut and carry system.

TRANSFER OF TECHNOLOGY

The extension activities such as demonstration of fodder production technologies in Farmers' Demonstration Block, Technology demonstrations on farmers' fields, Kisan Mela, Kisan Gosthi, Exhibitions, Radio/TV talks were regularly organised. Eight training programmes were also organised.

RRC, AVIKANAGAR

In berseem and lucerne, desirable level of increase (20-30%) in both green and dry fodder yields recorded at P-40 kg supplemented with VAM fungi. Inoculation of plants both with VAM and Rhizobium along with P-40 increased the total biomass (20-30%) and mutually enhanced the efficiency of each other.

In cowpea significant increase (20%) in biomass recorded with the amendments of saw dust @ 20 kg soil before 15 days of sowing along with VAM and Rhizobium.

Further increase (20%) in biomass was recorded in the root-knot nematode resistant cowpea variety C-152 by incorporating with VAM and Rhizobium.

RRC, DHARWAD

In agro-silvopastoral studies, *Pennisetum pedicellatum* perennial + *Stylosanthes scabra* mixture (24.07 t/ha) out yielded all combinations. The decreasing order of green fodder production (total of 3 cuts at 60 days interval) were from Deenanath perennial + *S. scabra, Brachiaria* + *S. scabra, Cenchrus* + *S. scabra*, PTH + *S. scabra* and *S. scabra* in pure stands.

Pennisetum trispecific hybrid on lower ridge and *Cenchrus* on upper ridge of bund recorded highest forage yield (5.0 kg/4m) followed by *Pennisetum* trispecific hybrid + *S. hamata* (4.35 kg), DHN-15 + *S. hamata* (4.20 kg) and IGFRI-3 + *Cenchrus ciliaris* (3.35 kg).

Among the fodder bajra varieties developed at the station, DRSB-2 has performed well in all the three years in AICRP trials.

The bajra X napier hybrid DHN-2 has exhibited superior performance in second year of evaluation also under coconut orchards at Goa Research Complex, Goa.

Occurrence of different diseases under field conditions was monitored in *Chloris guyana, Bothriochloa insculpta, B. pestura, Setaria spachelata*, *Dichanthium, D. aristatum, Desmanthus virgatus, Clitoria ternatea*, *Stylosanthes scabra* and *S. guianensis*.

2. INTRODUCTION

The Government of India established the Indian Grassland and Fodder Research Institute in the year 1962 at Jhansi. The administrative control of the Institute was taken over by the ICAR on April 1, 1966. The Institute is engaged in conducting, collating and coordinating research, training and extension programmes on all aspects of forage production and utilization at the national level. The research work in the field of forage crop improvement, crop production, grassland management, agro-silvopasture, seed technology and forage conservation has made significant contribution in evolving high yielding varieties of fodder and pasture crops and development of forage production and utilization technology and post-harvest technology. Technology transfer programmes are being taken up on high priority through PRA. The research programme has been re-oriented on the lines of thrust areas identified in the IGFRI VISION 2020.

MANDATE

- Collection, evaluation, documentation and conservation of forage genetic resources.
- Basic and strategic research on improvement, production and utilization of fodder crops and grasslands.
- Coordinating and collating research work on forages and grasslands.
- Providing consultancy and expertise in the area of forages and grasslands.
- Technology transfer and human resource development.

ORGANIZATION

The Institute is organized into seven multi-disciplinary research divisions and one research support service division. These are: (i) Crop Improvement (ii) Crop Production (iii) Grassland and Silvopasture Management (iv) Plant-Animal Relationship (v) Seed Technology (vi) Agricultural Engineering (vii) Economics and Extension and (viii) Informatics and Support Services.

Besides these divisions, the Institute has eight central units, *viz*., (i) Administration (ii) Audit and Accounts (iii) Estate (iv) Central Research Farm (v) PRA Cell (vi) Consultancy Cell (vii) HRD Unit and (viii) Medical Unit.

The Headquarters of All India Coordinated Project for Research on Forage Crops is located at the Institute. The Inter-Institutional Collaborative Network Programme on Crop based Livestock Feeding System is also in operation. The Institute houses research centres for All India Coordinated Research Projects on : (i) Dryland Agriculture (ii) Agroforestry (iii) Under-utilized/ Under-exploited Plants (iv) Farm Implements and Machinery Prototype Testing and Feasibility. The projects on (i) Monitoring of Varietal Improvement and Nucleus/Breeder Seed programme (ii) Development of DNA Fingerprints of forage crops using Random Amplified Polymorphic

DNA (RAPD) Assay (iii) Photosynthesis and Shade Tolerance in Tropical Range Grasses and Legumes (iv) Induction of Genetic Variability in *Trifolium alexandrinum* through Biotechnological Approach (v) Botanicals for the Management of Major Diseases and Pests of Forage Sorghum and Lucerne (vi) Productivity and Patterns of Nutrient turn over in selected Silvopastoral Systems in Semi-arid Central India (vii) VAM fungi in Management of Root-knot and Stunt Nematodes on Berseem, Lucerne and Cowpea and (viii) Development of Bio-physical Spreadsheet model of Tree/Grass Interactions for Silvopastoral System are also located at this Institute.

The Institute has one international project i.e. Indo-UK Collaborative Research Project on Forage Production.

The Institutes' three regional centres are located at Avikanagar in Rajasthan; Tegur near Dharwar in Karnataka and Srinagar in J&K. The temperate research programme has also been taken up at the IGFRI Centre, Palampur located in Himanchal Pradesh Krishi Vishwa Vidyalya campus to supplement the research activities of Srinagar Centre.

RESEARCH COLLABORATION

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

All India Coordinated Research Project on Forage Crops

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

Network Collaborative Project on Crop based Livestock Production System

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

National Seed Project

The National Seed Project located at this Institute is operative to strengthen the research capabilities for varietal improvement, varietal testing and uninterrupted basic and breeder seed production. The seed production of released or notified varieties of cultivated forage crops is taken up as per the allotment of Ministry of Agriculture and Project Coordinator (FC).

Indo-UK Collaborative Research Project on Forage production

The Indo-UK collaborative project on forage production has the major objectives to strengthen the research capabilities of the Institute. The components of the project include the bilateral research in frontier areas; training of IGFRI staff in UK, India and other countries; consultancy visits; acquisition of modern equipment; etc.

STAFF

The Institute has a sanctioned strength of 161 scientific, 156 technical, 83 administrative and 157 supporting staff. The staff position as on 31 March, 1998 is given in Chapter 15.

FINANCE

During the year 1996-97, the Institute utilized budget grant of Rs 702.35 lakhs, out of which Rs 111.50 lakhs were utilized under plan and Rs 588.84 lakhs under non-plan. This year a revenue of Rs 24.54 lakhs was realized. The statement of head-wise expenditure is given in Appendix I.

FACILITIES

Central Research Farm

The Institute farm has a total area of 500 ha, which also includes the area under campus. The farm has varying topography with *rakar, parwa, kabar* types of soils.

Administrative Wing and Research Laboratories

The Institute's building comprises of six laboratory wings and one administrative wing. There is well furnished Conference Hall, Training Hall and Committee Room for Symposia/Conference, etc. The laboratories are well equipped with sophisticated instruments. The Central Analytical Laboratory and Central Instrumentation Laboratory provide centralized services for chemical analysis and instrument repairs and maintenance.

ARIS Cell

The Institute has about 25 personal computers (Pentiums, 486, 386) connected over a Ethernet Local Area Network for information management and data analysis. The IRIX and UNIX servers are also connected to the network. The institute is having connectivity to national and international networks through NICNET.

Library

The Institute library accessioned 7854 books, besides, reports / bulletins / books received on complementary basis during the year. The library also subscribed for Indian and foreign journals. Library provides current awareness services to the scientists. The library consultation facility is provided to PhD scholars.

Photography and Art Unit

The photography and art unit undertakes the preparation of charts, maps, illustrations and slides.

Residential Complex

The residential campus named Krishi Nagar has 172 quarters of various categories. It has a community centre along with recreation and playground facilities with necessary infrastructure for providing better social life to the residents. State government aided primary school is also functioning in the Campus.

Scientist Home and Guest House

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

Medical Unit

The Medical Unit is located in the

premises of the Institute with a Medical Officer and other auxiliary staff for providing health care to the staff and their family members.

WEATHER

During the year 1997, a total rainfall of 986.4 mm was received in well distributed 52 rainy days. Onset of monsoons was recorded in 26th standard meteorological week (June 25 - July 1) and continued up to 37th standard meteorological week (Sept. 1 - 16). The month of October received a good amount of rainfall which was useful for *rabi* crops. A heavy amount (113 mm) of rainfall was recorded on 9th December, which is an unusual phenomenon.

The peak maximum temperature of 43.8 ^{0}C on 27th May and peak minimum temperature of 1.9 ^{0}C on 26th Jan. were recorded. The highest values of evaporation (22.7 mm/day) on 27th May, bright sunshine hours in a day (12.2 hr) on 7th June and wind velocity (16.5 km/hr) on 18th June were recorded. Maximum values of soil temperature of 52.0 ^{0}C at 5 cm depth on 25th April, 17th May and 14th June, 43.5^{0}C at 10 cm depth on 25th and 26th June and 39.0 ^{0}C at 20 cm depth on 26th June were recorded at 14.16 hours of the day (Table 1).

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

Months	Temp.^{o}C		RH% period		Rainfall (mm)	Rainy days (No.)	Wind velocity (km/hr)	Bright sunshine (Hrs./day)	Evaporation (mm/day)
	Max.	Min.	Ist	IInd					
Jan. 97	22.3	5.3	95	36	000.0	0	1.1	7.7	2.2
Feb. 97	27.3	8.3	91	32	000.0	0	2.9	9.9	4.2
Mar. 97	31.3	13.9	86	29	000.5	0	4.0	8.0	5.2
Apr. 97	36.1	18.3	65	26	021.4	2	4.8	9.5	7.7
May 97	39.7	22.9	54	30	017.0	3	6.9	10.1	12.1
June 97	38.5	25.9	65	37	050.4	6	7.5	9.1	12.1
July 97	33.9	25.7	88	61	171.8	13	5.6	4.2	5.5
Aug. 97	31.4	24.5	94	74	280.9	13	5.4	4.4	3.5
Sept. 97	32.9	23.8	91	64	147.7	5	1.5	6.8	4.2
Oct. 97	30.3	14.6	94	54	108.3	5	1.2	7.7	2.9
Nov. 97	25.8	13.5	97	56	029.1	2	1.4	6.0	1.9
Dec. 97	18.5	9.8	96	77	159.3	3	1.9	3.2	1.1

3. RESEARCH ACHIEVEMENTS

3.1 CROP IMPROVEMENT

GENETIC RESOURCES

Efforts have been made for enriching the genetic diversity in forage crops by conducting exploration trips and correspondence. Two explorations were undertaken (Bundelkhand districts of UP & MP and central districts of Rajasthan) for the collection of forage germplasms. 635 accessions of range grasses/cereals and 643 of range/cultivated legumes were added to the existing genepool. The present status of germplasm resource is given in table-2.

CULTIVATED CEREAL FODDERS

SORGHUM (*Sorghum bicolor*)

Evaluation of germplasm

Two hundred and sixty two "R" lines including eighty nine stay green lines have been evaluated for different traits. Wide range of variability was observed for various characters (Table 3).

Fourteen genotypes of fodder type viz, ICRISAT 8406 1-1-6-2-1, 1-1-5-3-1, ICSPHTPOP 61-1-1-1, GD 54652, 54655, 54671, 54738-1, 54812, GM 950431, 950433, 950437, 950439, SSV 12611, and thirteen stay green lines viz., SG 7, 31, 56, 57, 58, 64, 65, 67, 71, 72, 77, 80, IS 22380 have shown resistance to shoot fly in two consequent years.

Eighteen genotypes have shown resistant reaction to Anthracnose, zonate leaf spot, grey leaf spot, sooty stripe and leaf blight i.e., GD 54612, 54615, 54616, 54633, 54707, 54735-1, 54738-1, 54746, 54748, 54759, GM 950396, CSV 15, SG 24, 42, 43, 60 and SPV 1231. The genotype GD 54738-1 showed immune reaction to zonate leaf spot and leaf blight disease in both the years (*Kharif*, 1996 & 1997) and genotypes GD 54707 and GD 54759 showed resistant reaction to leaf blight in both the above years. The above lines can be used as a stable source for resistance.

Evaluation of F_1 hybrids

Fifty four F_1 were evaluated along with their parents (nine MS lines and six elite lines) to study their general and specific combining abilities (gca & sca). Among the nine male sterile lines, three lines i.e., SPDM 94022A, SPA2 94039A and MaldandiA showed higher gca component and in elite lines three lines i.e., (2077A x *S. aethiopicum*), (2219A x *S. aethiopicum*) and [(CS x Aispuri) x SPV 475] showed higher gca values. Among the 54 F_1's twenty F_1's (cross combinations) have shown positive sca for both green and dry fodder yield. The three superior cross combinations were identified for both green and dry fodder yield i.e., {SPA2 94039A x [(CS x Aispuri) x SPV 475]}, [SPDM 94022A x (2219A x *S. aethiopicum*)] and (SPDM 94022A x IS 2179) followed by (SP 40168 x SSG 59-3)] for green fodder yield and [SPA2 94012A x (2219A x *S. aethiopicum*)] and [MaldandiA x (2219A x *S. aethiopicum*) for dry fodder yield. The above three cross

Table 2 : Germplasm holding in forage crops

Species	Common Name	No. of Accessions
Trifolium alexandrinum	Egyptian clover/Berseem	594
Trifolium spp.	Clovers	15
Medicago sativa	Lucerne/Alfalfa	450
Vigna unguiculata	Cowpea	250
Lablab purpureus	Lablab bean/Sem	316
Clitoria ternatea	Butterfly pea	98
Stylosanthes hamata	Stylo	179
Stylosanthes scabra	Stylo	78
Stylosanthes guianensis	Stylo	139
Stylosanthes viscosa	Stylo	7
Stylosanthes humilis	Stylo	7
Stylosanthes spp.	Stylo	6
Macroptelium atropurpureum	Siratro	54
Desmenthus virgatus	Hedge lucerne	57
Centrosema pubescence	Centro	88
Desmodium spp.		32
Indigofera spp.		18
Melilotus spp.	Senji	16
Vicia spp.	Vetches	17
Atylosia spp.		15
Avena sativa	Oats/Jai	1200
Zea mays	Maize	212
Teosinte sp.		9
Sorghum bicolor	Sorghum	410
MS Lines of Sorghum		110
Pennisetum spp.		15
Panicum maximum	Guinea	198
Panicum antidotale		12
Cenchrus ciliaris	Buffel/Anjan Grass	389
Cenchrus setigerus	Black Anjan Grass	121
Cenchrus spp.		23
Dichanthium annulatum	Marvel Grass	253
Sehima nervosum	Sen Grass	52
Chrysopogon fulvus		50
Heteropogon contortus	Spear Grass/Lampa	76
Iseilema laxum	Flinder's Grass	45
Other Species		15

Table 3 : Range of variability and frequency distribution of "R" lines for the various characters

S.No. Characters	Range of the characters				
	No. of cultivars falling in each group				
1. Days to 50 % flowering	56 - 63 9	64 - 71 97	72 - 78 62	79 - 86 35	87 - 93 59
2. Plant height (cm)	59 - 128 10	129 - 197 40	198 - 266 94	267 - 365 114	366 - 404 4
3. No. of leaves/plant	5.3-8.0 5	8.1 - 10.7 16	10.8 - 13.4 79	13.5 - 16.1 137	16.2 - 18.8 25
4. Leaf length (cm)	35 - 48 6	49 - 61 99	62 - 74 117	75 - 88 31	89 - 101 9
5. Leaf width (cm)	3.5 - 4.8 8	4.9 - 6.1 40	6.2 - 7.5 101	7.6 - 8.8 88	8.9 - 10 25
6. Stem girth (cm)	0.9 - 1.2 6	1.3 - 1.6 62	1.7 - 1.9 134	2.0 - 2.3 52	2.4 - 2.6 8
7. GFY/plant (g)	110 - 312 35	313 - 514 102	515 - 716 98	717 - 918 24	919 -1120 3
8. DFY/plant (g)	27 - 87 31	88 - 157 127	158 - 207 63	208 - 267 32	268 - 327 9
9. Sugar Percentage (brix)	2 - 5 60	6 - 8 94	9 - 11 64	12 - 14 35	15 - 17 9

combinations are superior than the control hybrid CSH 13-R.

Five hybrids i.e., SP 40168 x IS 2179, SP 40168 x SSG 59-3, [SP 40168 x (2219A x *S. aethiopicum*)], [SP 40168 x (2219A x Etawah-2)] and {SP 40168A x [(CS x Aispuri) x SPV 475]} were compared with their parent SP 40168A and Check CSH 13R. All the hybrids are superior to the parent as well as check in photosynthetic rate, biomass production and the leaf area index. However, the transpiration rate in all the hybrids and parents are less than check CSH 13R (4.8 µ mol/m^2/s). The highest photosynthetic rate was observed in the hybrid {SP 40168 x (2219A x *S. aethiopicum*)} (39.44 µ mol/m^2/s) followed by SP 40168 x IS 2179 (38.07 µ/mol/m^2/s) but the dry biomass production is same in both the cases (2186 g/m^2)

which may be due to the high specific leaf weight in both the cases (587 & 508 mg/dm^2). However the total chlorophyll content is more in {SP 40168A x [(CS x Aispuri) x SPV 475]} (2.24 mg/gfw) followed by SP 40168A x (2219A x Etawah-2) and CSH 13R.

Hybridization and advancing of filial generations

Large number of crosses were attempted using series of male sterile lines and 58 crosses were obtained (Table 4).

Male sterile lines

Sixty seven male sterile lines (A1, A2 and A4 cytoplasm) alongwith maintainer lines from ICRISAT were evaluated for hybridization programme. The data on growth parameters were recorded on fifty male sterile lines alongwith their maintainers for nine plant characters at 50 per cent emergence stage of the spike. Wide range of variability was observed for all the plant characters (Table 5).

Based on overall performance, 9 superior forage type male sterile lines were identified DM 94006, LB 94012, GM 94052, DL 94041, SPA2 94010, 94031, 94033, 94036 and ICSA 91001. Twenty four male sterile lines along with their maintainers showed resistant for mycological diseases such as Anthracnose, zonate, sooty stripe and grey leaf spot.

Nine male sterile lines along with their maintainers showed resistance for shootfly incidence viz., SPA2 94006, DM 94022, SFR 94027, SFR 94031, SFPR 94019, SPA2 94003, SPGM 94055, SPGM 94073 & ICSA 90004. Whereas, six male sterile lines along with their maintainers have showed complete resistance for insect pests and diseases namely DM 94022, SPA2 94003, SFR 94031, SPA2 94009, ICDA 88001 and ICSA 90004 and four male sterile lines along with their maintainers showed superiority for forage attributes along with resistance to diseases i.e., SPA2 94010, SPA2 94031, SPA2 94036 and ICSA 91001.

Initial evaluation of strains

Single cut: 29 selected strains were evaluated in RBD with two replications with CSV 15 as check. The observations were recorded at 50 per cent flowering stage on eight characters which showed significant differences between the varietal means.

Based on ten per cent superiority both in terms of fresh weight (g/plant) and dry weight (g/plant), the twelve strains were identified namely, ICRISAT 8406 1-1-6-1-2, 1-1-6-2-1, GD 54611, GD 54629, GD 54630, GD 54637, GD 54643, GD 54675, GD 54682, GD 54659, SSV 12611, GD 54795. Out of which seven genotypes are of stay green nature and expressed resistance to leaf spot diseases viz., ICRISAT 8406 1-1-6-1-2, 1-1-6-2-1, GD 54611, GD 54637, GD 54643, GD 54659 and GD 54795.

Final evaluation of promising strains

Single cut: Eleven superior strains containing two hybrid derivatives and nine selections were planted in R.B.D. along with a national check HC-171, in two replications. Keeping in view the ten per cent superiority

Table 4 : Details of Filial generation and their advancement

Filial generation	No. of crosses	No. of single plant progenies planted	No. of single plant progenies selected in the next generation	
F_1	79	-	85	(F_2)
F_2	27	46	62	(F_3)
F_3	16	86	78	(F_4)
F_4	31	143	171	(F_5)
F_5	14	33	21	(F_6)
F_6	14	75	77	(F_7)

Table 5 : Range of variability and frequency distribution of 50 male sterile lines along with their maintainers for various characters

S.No. Characters	Range of the characters				
	No. of cultivars falling in each group				
1. Days to 50% flowering	58 - 62 13	63 - 66 28	67 - 70 36	71 - 74 22	75 - 78 1
2. Plant height (cm)	75 - 105 12	106 - 135 23	136 - 165 35	166 - 195 27	196 - 225 3
3. No. of leaves/plant	8.5-10.1 5	10.2- 11.7 13	11.8 - 13.3 22	13.4 - 14.9 29	15.0 - 16.7 15
4. Leaf length (cm)	51 - 57 5	58 - 63 13	64 - 70 22	71 - 76 42	77 - 82 18
5. Leaf width (cm)	6.0 - 6.9 11	7.0 - 7.8 18	7.9 - 8.7 42	8.8 - 9.6 20	9.7 - 10.5 9
6. Stem girth (cm)	1.4 - 1.7 12	1.8 - 2.0 37	2.1 - 2.3 30	2.4 - 2.6 18	2.7 - 2.9 3
7. GFY/plant (g)	172 - 308 15	309 - 444 36	445 - 580 29	581 - 716 16	717 - 852 4
8. DFY/plant (g)	63 - 102 22	103 - 141 38	142 - 180 30	181 - 219 9	220 - 258 1
9. Sugar Percentage (brix)	6 - 8.3 24	8.4- 10.6 44	10.7- 12.9 14	13 - 15.2 15	15.3- 17.5 3

over check for green and dry fodder yields, the four strains viz., 2077A x S aethiopicum 14-4-7-1-, SC 793, SC 814 and IS 2179 were selected.

IGFRI entries in all India co-ordinated trial

Single cut

(Initial varietal trial) - HD 20, HD 21

(Final varietal trial) - HD 17 ,HD 15

Multicut

(Initial varietal trial) - HD 18, HD 19

Evaluation of stay green germplasm

Eighty nine stay green lines received from ICRISAT were evaluated along with institute genetic stock. The data was recorded on various growth parameters at 50 per cent flowering and wide variability was observed (Table 6).

Seventeen genotypes showed superior performance over the check and resistant to shoot fly and major diseases i.e., SG 6, SG 7, SG 12, SG 15, SG 22, SG 29, SG 35, SG 36, SG 39, SG 53, SG 70, SG 71, SG 73, SG 74 and N-13.

Nutritional evaluation of stay green vis-a-vis go-brown varieties

Samples of four sorghum varieties were analysed namely (CSx Aispuri) x SPV 475), IS 2179 x *S. aethiopicum* which were relatively stay green than IS 2179 x I 1-3-1 and IS 4859 at the time of grain maturity. Leaves had twice protein content than stems. Stay green varieties had 2 to 5 units more crude protein contents than go brown varieties. Dry matter, NDF, ADF, Ash and lignin contents except cellulose and OM were higher in leaves than stems of test varieties. IVDMD and Organic matter digestibility was significantly higher in both fractions of stay green than go brown varieties. Highest IVDMD was recorded in leaves (73.52) and stem (62.9%) of G1 variety as compared to others. Within varieties leaves exhibited 5 to 10 units more IVDMD than the stems. Leaves and stems of stay green varieties had significantly higher DM, NDF & ADF disappearance than go brown at 48 hrs of incubation. Rate of NDF disappearance in stems and leaves of stay green varieties ranged from 48.14 - 61.11 against 41.60 - 51.54 % in go brown varieties respectively. This study shows that stay green varieties are rich in crude protein and better in DM digestibility as compared to go brown varieties.

Performance of selected stay green lines

Twenty selected strains comprising 15 stay green and five go-brown lines were evaluated for green and dry matter yield . Four genotypes show superiority i.e., A 2267-2, GSS 2, SPV 1284 and CSV 15 among stay green lines followed by B 24 on dry weight basis (Table 7). Among go-rown lines, HD 15 and J sel 10 expressed superiority for green and dry fodder yield. All the genotypes were resistant to shoot borer and important diseases.

Prevalence of diseases : Severe incidences of anthracnose (*Colletotrichum graminicola*), Zonate leaf spot (*Gloeocercospora sorghi*), Sooty stripe (*Ramulispora sorghi*) and Grey leaf spot

Table 6: Range of variability and frequency distribution of Stay green lines for the various characters

S.No. Characters	Range of the characters				
	No. of cultivars falling in each group				
1. Days to 50% flowering	65 - 71 34	72 - 76 8	77 - 82 3	83 - 87 13	88 - 93 31
2. Plant height (cm)	59 - 112 7	113 - 165 8	166 - 218 16	219 - 271 27	272 - 325 31
3. No. of leaves/plant	10.5-11.8 7	11.9- 13.1 14	13.2 - 14.4 24	14.5 - 15.7 29	15.8 - 17.0 15
4. Leaf length (cm)	35 - 44 1	45 - 53 3	54 - 62 38	63 - 70 33	71 - 80 14
5. Leaf width (cm)	5.8 - 6.7 13	6.8 - 7.6 29	7.7 - 8.5 36	8.6 - 9.4 9	9.5 - 10.3 2
6. Stem girth (cm)	1.3 - 1.5 10	1.6 - 1.8 44	1.9 - 2.1 23	2.2 - 2.3 10	2.4 - 2.6 2
7. GFY/plant (g)	176 - 314 3	315 - 452 20	453 - 590 32	591 - 728 26	729 - 866 8
8. DFY/plant (g)	45 - 93 6	94 - 141 31	142 - 189 25	190 - 237 19	238 - 285 8
9. Sugar Percentage (brix)	3 - 5 20	6 - 8 31	9 - 11 14	12 - 14 20	15 - 17 4

(*Cercospora sorghi*) were recorded in sorghum.

Epidemic development of anthracnose: Maximum disease development and spread in relation to time and various environmental factors was during 15-30 Aug, 1997. The size and number of the lesions (leaf spots) increased from 1-5 to more than 50 per leaf.

Differentials of anthracnose disease: Seventeen differentials were screened under net house conditions. Artificial inoculations of *Colletotrichum graminicola* (Jhansi isolate) were made. Dark red spots on leaf and mid rib developed on many of the differentials. Minimum disease index

Table 7 : Performance of the selected stay green lines

	50 days after sowing	50 percent flowering	Maturity	20 days after maturity	average of 4 stages
GFY/plant (g)					
1. SPV 1284	216(12)	573(3)	533(4)	452(6)	444(3)
2. A 2267-2	253(4)	619(2)	572(2)	556(2)	500(2)
3. GSS 2	284(1)	715(1)	565(3)	577(1)	535(1)
4. CSV 15	262(2)	513(5)	576(1)	482(4)	418(5)
DFY/plant(g)					
1. SPV 1284	25(6)	127(5)	131(2)	132(5)	104(5)
2. A 2267-2	25(6)	130(3)	124(4)	142(2)	106(4)
3. GSS 2	27(4)	169(1)	130(3)	125(6)	113(1)
4. CSV 15	26(5)	129(4)	140(1)	140(3)	109(3)
5. B 24	21(8)	138(2)	120(5)	160(1)	110(2)

Figures in parenthesis indicate rank of lines

(12.2) was recorded on IS-6958 and IS-6928.

***In-vitro* evaluation of botanicals against *Colletotrichum graminicola* :** Five neem based products *viz*. Neemazal, Suneem, Bioneem, Nemactin and Achook along with Neem Seed Kernel Extract (NSKE) were tested in laboratory for their fungal toxicity to *C. graminicola.* All the botanicals significantly reduced the mycelial growth and spore germination. However, maximum reduction 90 and 78 percent in spore germination and mycelial growth respectively was recorded due to NSKE 2%.

Seed ageing and its alleviation: Hydrated-dehydrated and unhydrated seeds of variety HC-136, dry dressed with calcium hypochlorite and *Albizia amara* leaf powder separetly stored in polythene bags along with untreated control during 1995, were studied to assess the membrane permeability(solute leakage percentage) and lipid peroxidation (Malondialdehyde content), improvement in seedling emergence and plant vigour.

Minimum solute leakage 36.2 percent was found in one hour hydrated-dehydrated seed, dry dressed with calcium hypochlorite as compared to 48 percent solute leakage in control. Lowest malondialdehyde content (24.51 µ mole per axis) was recorded in unhydrated seed dry dressed with calcium hypochlorite as compared to untreated seed (33.86 µ mole per axis). Seed hydrated in water for two hours and dried to original moisture content then dry dressed with calcium

hypochlorite and *Albizia amara* leaf powder separately recorded 100 and 49 percent seedling emergence as compared to 96 percent in control. Highest dry weight 4.27g per plant (one month old) was recorded in unhydrated seed dry dressed with calcium hypochlorite as compared to 3.12g per plant in untreated control, whereas hydrated-dehydrated seed dry dressed with *Albizia amara* leaf powder gave lowest dry matter yield (1.38g per plant).

OATS (*Avena sativa*)

Interspecific back-cross-derived progenies (*Avena sativa* x *A. sterilis*)

Evaluation of 12 selected back-cross progenies against the check, UPO-212 under multicut revealed the superiority of (OS-6 x *A. sterilis*)-3-1 and (OS-6 x *A. sterilis*)-432-6 for green forage yield by a margin of 29.5 to 49.6%. These entries were also superior with respect to regeneration and tillering potential.

Dual-purpose (forage-cum-grain) oats

Replicated trial of 52 selected oat collections of indigenous and exotic origin indicated the superiority of two entries namely IGO-373 and PI-466865 for both green forage yield and seed yield. The entries like IGO-372, IGO-373 and IGO-371 were almost at par with the check for green forage but slightly superior for seed yield.

Advance generation selections

Out of 56 intraspecific selections tested in a replicated trial against the check UPO-212 under multicut, seven progenies excelled the check for green forage by 3.1 to 19.8%. These lines also had high leafiness with dark green colour.

Performance trial of 32 selections of intervarietal origin with respect to forage yield under multicut exhibited the superiority of the entries viz. (PA-8224 x OS-6) x (K-10 x UPO-94)-2, (OS-7 x IGO-320) x JHO-851, (OS-6 x IGO-320)-92H - 44, (OS-7 x IGO-320)-5 and (OS-7 x IGO-320)-4-1-8 over the check. The range of superiority was 25.0 to 44.6%.

Interspecific hybridization

One of the wild oats, *Avena sterilis* (2n = 6x =42) having desirable genes like high growth rate, high protein content and high biomass production potential was utilized in crossing programme with promising female parental stocks namely JHO-851, UPO-212, IGO-320, Cuahtemoc and Pennline of the cultivated species *A. sativa*. A large number of crosses were attempted for different combinations.

Amphiploid-derived progenies (*Avena sativa* x *A. maroccana*)

Sixty six progenies derived from interspecific cross *A. sativa* x *A. maroccana* in A_{12} generation were selected for performance trial in term of forage yield under multicut. A number of lines having chromosomal stability at hexaploid level (2n = 6x =42) viz. 20/71, 18/37, 32/5, 30/11 and 21/51 registered superiority ranging from 2.5 to 12.6% over the check. These progenies also had high leaf/stem ratio and dark green coloured leaves.

All India coordinated trial

Three oat strains (JHO-96-1, 96-2 and 96-3) were tested in initial evaluation trial (single cut). JHO-96-1 excelled the national check by a margin of 18.9% and 19.7% in North-West and hill zone, respectively for green forage yield. JHO-96-2 gave higher green forage yield to the extent of 10.0% and 5.2% over the check in South and hill zone respectively, while for dry matter yield it was superior than the check by 21.8% and 10.8% in North-East zone and on all India basis respectively.

Three oat entries (JHO-96-4, 96-5 and 96-6) were tested alongwith 13 other genotypes under initial evaluation trial (multicut). The entry, JHO-96-6 was observed to be at par with control with respect to forage yield, however, its performance for leafiness was far superior than the check (UPO-212).

Five institute entries (JHO-9 along 4-1, 94-3, 94-4, 95-1 and 95-2) were tested with 13 other genotypes in Advance Varietal trial (multicut). In zonal performance, JHO-94-3, 95-1 and 95-2 excelled for green forage yield over the check by a margin of 46.0 to 69.7% in South zone, while in Central zone JHO-94-1 and 95-2 produced higher green forage than the check. In North-West zone, JHO-94-3 registered 8.6% increase over the check in green forage. On the basis of dry matter yield JHO-94-3 registered superiority of 33.0% over the check, UPO-212.

Chemical compositions and dry matter degradability

Out of 18 varieties evaluated for quality parameters, the entries JHO-94-1, JHO-94-4, JHO-95-1, JHO-95-2 developed at Jhansi were found superior than the other entries including the checks (Kent and UPO-212) for dry matter degradability, crude protein and lower fiber content (Table 8). The entry JHO-94-1 gave the highest values for dry matter degradability which continued under successive cuts.

MAIZE (*Zea mays*)

Germplasm evaluation

Three hundred and twenty three accessions (Collections from Bihar, Andhra Pradesh, Tarai area of Uttar Pradesh and Delhi) of fodder type maize were evaluated for genetic variability. Correlation studies indicated that green fodder yield was significant and positively associated with plant height (0.470**), number of leaves (0.379*), leaf length (0.332*), leaf width (0.442**) and leaf stem ratio (0.405**). On the basis of principal component and non-hierarchical Euclidean cluster analysis accessions were classified into 12 groups. Group VIII was the largest consisting of 35 genotypes, while group III was smallest with 18 genotypes. Maximum eigen root value (3.68) was obtained by eigen vector 1 and the first four principal components calculated using standard variables accounted for 45.98%, 14.06%, 12.94% and 8.66% of variation. The intra-cluster distance ranged from 1.56 to 2.29 and highest inter-cluster distance (4.73) was between cluster I and X. The potential genetic donors for green fodder yield were observed to be IG-97-16, IG-97-19, IG-97-20, IG-97-23, IG-97-25, IG-97-37, IG-97-53, IG-97-54, IG-97-55, IG-97-60, IG-97-78, IG-97-86, IG-97-90, IG-97-97, IG-96-34, IG-96-

Table 8 : Chemical composition and dry matter degradability of oat varieties tested in advance varietal trial (multicut) at Jhansi (on dry matter basis)

Variety	DM degradability by nylon bag technique (%)		CP %		NDF %		ADF %		Ash %	
	Ist cut	IInd cut	Ist cut	IInd cut	Ist cut	IInd cut	Ist cut	IInd cut	Istcut	IInd cut
OL-805	79.47	64.55	21.34	12.75	46.91	58.31	30.12	41.22	11.11	12.20
OL-936	76.59	61.26	16.90	11.20	45.07	60.20	28.30	40.53	11.20	11.92
OL-966	73.56	58.51	22.07	13.31	46.11	64.51	29.13	41.22	11.57	12.56
OL-970	87.94	69.56	20.17	12.08	45.12	56.92	30.70	40.97	10.92	11.95
JHO-94-1	90.91	71.80	21.34	12.32	44.15	57.08	30.50	38.90	11.06	10.17
JHO-94-3	85.18	55.05	21.67	11.74	47.40	63.50	32.60	39.85	11.77	11.75
JHO-94-4	85.72	69.66	20.14	12.15	47.09	58.27	31.20	39.06	10.91	11.00
JHO-95-1	88.33	68.08	21.87	12.92	44.32	60.03	28.12	38.14	10.72	11.91
JHO-95-2	84.16	70.76	19.89	13.20	43.46	55.93	24.15	39.73	10.09	10.97
OS-242	81.79	61.32	20.54	11.34	45.80	65.45	28.80	42.20	10.89	12.01
OS-245	84.65	62.88	19.77	12.81	45.17	63.11	29.92	41.31	10.97	11.95
OS-285	83.09	66.23	18.41	11.95	45.32	60.16	30.51	40.17	11.02	11.57
DFO-54/254	78.32	62.67	18.87	14.47	47.50	54.80	28.10	36.00	12.83	12.42
UPO-240	81.73	67.32	19.03	14.01	44.17	55.70	27.98	37.33	11.44	12.22
UPO-246	82.28	66.32	21.87	13.73	45.82	60.55	29.72	40.11	10.66	11.75
UPO-249	74.51	65.13	18.91	12.90	46.85	61.31	30.22	39.67	10.53	11.51
UPO-212(C)	79.71	65.75	21.07	13.01	46.01	63.50	30.16	40.05	10.91	11.52
Kent (C)	81.45	63.64	18.49	12.80	43.10	60.71	28.80	38.52	10.48	11.06

49, IG-94-2, IG-94-6, IG-94-11, IG-94-17, IG-94-29, IG-94-54 and IG-94-102.

Germplasm evaluation of wild relatives

Teosintes like Teo-4, Teo-5, Teo-6, *Zea diploperennis* #1, *Z. diploperennis* # 2, *Z. luxurians* # 1, *Z. luxurians* # 2, *Z. parviglumis* # 2, Teosinte Balsas # 8756, Teosinte Balsas # 8757, Teosinte Balsas # 8760, Teosinte Balsas # 8761, Teosinte Balsas # 8766 (obtained from IARI, New Delhi) were evaluated in RBD with 3 replications during the first year of growth period for various morphological descriptors. Teo-6 was found to give best performance for forage yield and related attributes.

Progeny selection of Teomaize

F_1 hybrids of maize and teosinte, viz. Paras x Teo 6, N4 x Teo 6, Murli x Teo 6, T1 x Teo 6, S 23 x Teo 6, T26 x Teo 6, T2 x Teo 6 and S2 x Teo 6 (obtained from IARI, New Delhi) were screened for fodder yield, disease and insect resistance and were also maintained by selfing for further selection in F_2 and onward generations.

Correlation and path analysis

Fifty three diverse accessions of fodder types in maize were grown in RBD with 3 replications, along with African Tall as standard check. Pooled analysis for association relationship depicted that green fodder yield was positively correlated with plant height, number of leaves, leaf length, leaf width and leaf stem ratio. Path coefficient analysis (pooled) revealed highest and positive contribution of plant height towards green fodder yield followed by leaf length, number of leaves, leaf stem ratio and leaf width, respectively (Fig. 1).

Screening for nematode resistance

Genotypes of fodder maize (323 accessions) and various teosintes were screened against root lesion nematode (*Pratylenchus zeae* Graham, 1951). IG-94-44, IG-94-47, IG-96-3, IG-96-7, IG-96-11, IG-96-19, IG-96-29, IG-96-39, IG-97-6 and IG-97-10 strains in fodder maize and *Z. diploperennis* # 2 and *Z. parviglumis* # 2 in teosintes were found to be resistant against root lesion nematode (*Pratylenchus zeae*). None of the genotypes were found to be free and immune from this nematode.

Screening of germplasm against major insect pests

Five entries out of 53 new accessions viz. IG-96-7, 96-25, 96-29, 96-39 and 96042 were found to be tolerant to the attack of defoliators under natural infestation conditions.

Six entries viz 94-24, 94-44, 94-47, 94-130, 94-140 and 94-142 out of 171 old accessions were found to be tolerant to defoliator pests under field conditions.

Entomological evaluation of Teosinte parental material and F_1 hybrid

Eight lines out of 43 accessions viz. T4 (*Z. diploperennis*-1), T5 (*Z. diploperennis*-2), H-8 (Murli x Teo 6), H-11 (PARAS x Teo 6 plump), H-15 (T1 x Teo 6), H-23 (T2 x Teo 6), H-24 (T2 x Teo 6) and H-29 (S2 x Teo 6) were moderately tolerant to the attack of defoliator pests.

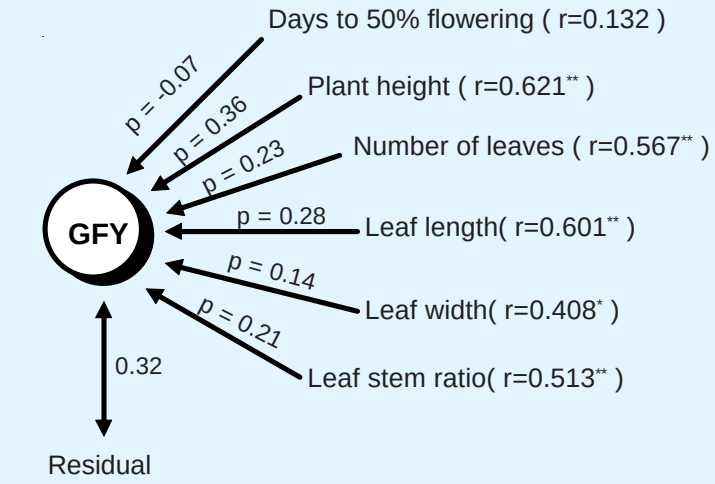


Fig. 1 : Cause and effect relationship of green fodder yield with a few morphological attributes in fodder maize

Screening of new germplasm lines

Two cultivars out of 100 lines were resistant whereas 5 cultivars were moderately tolerant to the attack of defoliators.

One hundred lines of maize including Teosinte, African tall and some F_1 lines were screened. During the screening various diseases like leaf spots caused by *Helminthosporium turcicum*, Diplodia macrospora, Brown spots caused by *Physoderma maydis* and rust (*Puccinia sorghi*) were observed, but incidence of *Diplodia, Physoderma* and *Puccinia* were not significant. However, the incidence of *Helminthosporium* was prominent. The lines showed various degree of resistance from moderate to susceptible class. The highly resistant lines include IG-966-1, 96-9, 96-40,966-53,94-5,94-117,T-2,T-13, PFM-1 and PFM-89.

Nutritive evaluation of genotypes

Leaves and stems of seventeen genotypes of maize were collected at 50% of flowering and analysed individually for chemical composition and dry matter digestibility. The crude protein (CP) content in stem and leaves of different genotype ranged from 3.49 to 6.95 and 10.20 to 12.92%, respectively. The NDF, hemicellulose and ash except OM & lignin contents were higher in leaves than stems of different genotypes. The lignin content in leaves and stems of various genotypes differed from 3.86 to 10.11 and 4.03 to 11.85% respectively. The IVDMD and in sacco DM disappearance in leaves and stems of different genotypes

varied from 50-72%. Leaves had significantly (P< 0.05) higher IVDMD and in sacco NDF and ADF degradation than stem. Genotypes IG-96-1,9, 96-1, 96-14, 96-5, 96-6, 96-7 and 96-15 had higher crude protein and dry matter digestibility (Table 9).

PENNISETUMS

Procurement and establishment of germplasm

In order to enrich the existing genepool, diverse germplasm of various species was obtained from ICRISAT, Hyderabad and through explorations. Accessions of *P. pedicellatum, P. polystachyon, P.orientale, P.violaceum and P. glaucum* (male sterile and maintainer lines) were received and established in the nursery.

Interspecific hybridization

Interspecific hybridization was carried out between the target species using male sterile lines of bajra as female parent and apomictic species as male/donor parent. These crosses resulted in mostly shrivelled seeds.

Embryo rescue

To overcome the problem of embryo abortion embryo culture was standardized utilizing immature embryo (12-15 days old) from control crosses of *P. glaucum* x *P. glaucum* and viable seedlings were obtained.

Table 9 : In sacco DM, NDF and ADF digestibility in maize genotypes

Genotypes	DM (%)		NDF (%)		ADF (%)	
	Leaf	Stem	Leaf	Stem	Leaf	Stem
IG-96-2	70.13	61.07	57.88	49.67	50.83	42.07
IG-96-3	69.64	60.17	53.71	47.90	49.78	40.49
IG-96-4	69.15	55.09	51.73	48.35	48.75	40.52
IG-96-5	62.36	52.72	48.76	42.75	45.98	40.06
IG-96-6	69.32	53.16	47.67	41.69	43.93	39.13
IG-96-7	70.15	53.33	55.36	45.93	49.71	38.40
IG-96-11	62.66	54.27	54.00	42.98	45.26	40.08
IG-96-13	67.37	54.93	52.43	43.18	45.86	39.74
IG-96-14	69.24	55.06	52.42	46.84	47.23	41.15
IG-96-15	66.49	54.36	57.08	42.89	45.35	40.14
Over all mean	67.48	55.39	52.74	45.12	47.21	40.15
SEM	0.57	0.55	0.56	0.54	0.48	0.31

Interspecific variation/relationship

For estimating the relationship between various lines/ accessions of *Pennisetum* species and to identify species closer to *P. glaucum*, biochemical analyses utilizing isozyme behaviour were carried out. Isozymes of peroxidase, acid phosphatase, alkaline phosphatase, esterase, superoxide dismutase, aspartate amino transferase were compared between species. Similarity index matrix show that *P. glaucum* is closely related with *P. violaceum* followed by *P. squamulatum* and *P. purpureum* (Table 10).

Biochemical characterization

Isozyme studies were performed on already established interspecific hybrids (N-B, Trispecifc hybrid, *P.glaucum x P. orientale*) and their progenies for understanding the transfer of isozyme alleles from parental species to respective interspecific crosses.

CULTIVATED FODDER LEGUMES

COWPEA (*Vigna unguiculata*)

Germplasm evaluation

A total of 191 hybrid derived lines were evaluated alongwith two checks Bundel Lobia-1 and Bundel Lobia-2 for various morphogenetical attributes and categorised by using non Hierarchial Euclidean cluster analysis. Cluster V being the largest comprising 37 accessions, while cluster VIII being the smallest was represented by just

Table 10 : Similarity index values for pairwise comparisons between different *Pennisetum* sp.

	Poly 236	Poly 205	Squa	Purp	Glau	Viol	Ori	Pedi
Poly 236								
Poly 205	100							
Squa	20.69	20.69						
Purp	37.04	37.04	38.46					
Glau	14.71	14.71	35.71	21.21				
Viol	18.75	18.75	48.00	30.00	57.69			
Ori	25.00	25.00	13.53	19.23	13.79	11.76		
Pedi	20.83	20.83	7.14	12.5	7.40	9.68	21.74	

Poly 236 = *P. polystachyon* (IG-96 -236)
Poly 205 = *P. polystachyon* (IG-96 -205)
Squa = *P. squamulatum*
Purp = *P. purpureum*
Glau = *P. glaucum*
Viol = *P. violaceum*
Ori = *P. orientale*
Pedi = *P. pedicellatum*

8 genotypes (Table 11). All the clusters were found to be homogeneous as far as intra-cluster variation was concerned (Table 12) for inter-cluster diversity cluster III and cluster X were found to be having the maximum distance (Table 12), which could be utilized in selecting the parents for future hybridization programme. Clusters VI and cluster X comprised of accessions having highest green weight while a high L/S ratio was represented by cluster IV which had moderate green fodder yield (Table 11).

Screening for insect pest resistance

Cowpea hybrid derivative lines were screened for identifying source of resistance towards flea beetles, semiloopers, jassids and aphids under field conditions. Out of 191 lines, six lines *viz.* V13, V32, V43, V96, V120 and V143 were found most resistance against all the major insect pests. Nine lines viz. V 32, V38, V43, V120, V126, V96, V164, V143, V150 were found highly tolerant against semiloopers and flea beetles, while V 65, V68, V112, V132, V158 were tolerant against semiloopers and V67, V132, V133, V154, V155, V156, V162, V176, V183, V189 against flea beetle.

All India coordinated trials

Initial evaluation trial : In a trial comprising 10 entries, IGFRI entry IFC-9701 gave the maximum green fodder yield (275 q/ha) which was 10% higher than that of check variety Bundel Lobia-1 (250 q/ha). The other Institute entry IFC-9702 (347.22 q/ha) performed at par with the check variety.

Final evaluation trial : Institute entry IFC-9503 (300 q/ha) gave the maximum green fodder yield in trial comprising 8 entries. The other entry IFC-9502 (275 q/ha) also performed better than the check variety Bundel Lobia-1 (248 q/ha).

Screening for insect pest resistance

In the KBTC-1 trial, CL-345 and 370 were found highly tolerant against flea beetles and IFC-9701, UPC-605, CL-375 against semiloopers.

In KBTC-2 trial, UPC-951 and 953 showed high tolerance against semiloopers while UPC-951, 953, 603, S286, IGFRI-9502 against flea beetles. The overall performance of UPC 953 was the best against all the major insect pests. No aphid incidence occurred while leaf minor intensity was quite low this year.

Screening against key nematodes

Eighteen varieties of cowpea in coordinated trials were screened against two key nematode species *i.e., Meloidogyne incognita* and *M. javanica*. Two varieties *viz.* IFC 9702 and CL 373 were found to be resistant to both the nematode species.

Disease management

Management of root-rot disease complex of cowpea caused by root-knot nematode *Meloidogyne incognita* and three fungi viz. *Rhizoctonia solani, Fusarium semitactum* and *Pythium aphenidermatum* was conducted under artificial inoculation conditions consisting of 8 treatments in 4 replicates.The results indicated a significant reduction in disease intensity (58%) increase in plant growth (45%) and P uptake

Table 11 : Clustering pattern in cowpea germplasm alongwith number of accessions comprising them and mean values for few important morphological traits

Cluster	No. of Accessions	Plant Height (cm)	No.of Primary Branches	No.of Secondary Branches	No.of Nodes	Green weight/plant (gm)	Leaf/Stem Ratio
I	30	118.40	6.06	4.69	16.14	150.85	0.53
II	16	125.79	5.98	7.02	17.50	157.92	0.55
III	18	115.63	4.13	3.07	15.31	69.26	0.52
IV	13	144.02	5.67	5.51	20.05	122.09	0.69
V	37	131.05	4.80	3.87	17.42	105.83	0.45
VI	11	129.85	5.85	5.94	19.00	229.26	0.49
VII	18	164.11	4.20	3.13	18.58	89.16	0.52
VIII	8	190.75	5.62	4.92	22.04	72.16	0.41
IX	28	121.99	5.93	4.76	17.12	110.11	0.47
X	12	170.99	6.64	6.78	23.69	204.44	0.53

Table 12 : Average distance of cluster members from cluster centroids and distances between cluster centroids

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X
I	2.405									
II	2.719	2.843								
III	3.188	3.685	2.831							
IV	3.212	3.385	3.616	2.925						
V	2.239	3.015	2.646	3.569	2.324					
VI	3.079	3.055	4.908	4.172	2.810	2.668				
VII	3.515	4.034	3.025	3.414	2.592	4.055	2.711			
VIII	4.156	4.382	4.598	3.614	4.307	4.583	3.860	2.910		
IX	2.536	3.168	3.337	2.964	2.464	3.473	3.488	4.852	2.380	
X	3.683	3.373	5.311	3.234	3.822	2.855	4.034	3.373	3.657	2.931

(52%) when neem cake was applied together with VAM fungi *Glomus fasciculatum* inoculations. Moreover, in this treatment percent root colonization and number of VAM spores in the soil was also found to be greatly enhanced. VAM fungi has thus proved to be a potential biocontrol agent and also helps in nutrient uptake.

Seed ageing and its alleviation

Air dried seeds of variety IGFRI-450, dry dressed with calcium hypochlorite, immersed in acetone containing p-hydroxybenzoic acid, p-aminobenzoic acid, potassium iodide 10^{-3} M each and *Albizia amara* leaf powder separately for two durations (2 and 4 hours) and stored in polythene bags along with untreated control during 1995, were studied to assess the reduction in solute leakage and malondialdehyde content, improvement in seedling emergence and plant vigour. Minimum solute leakage (36.84 percent) was recorded in the seed invigorated with potassium iodide for two hours followed by 42.86 percent in dry dressed with calcium hypochlorite as compared to 45.83 percent in untreated seeds. Lowest content of malondialdehyde (27.53 µ mole per axis) was recorded in the seeds invigorated with potassium iodide for four hours followed by 33.33 µ mole per axis in p-aminobenzoic acid(2 hrs) invigorated seeds as compared to 56.99 µ mole per axis in untreated control. Highest seedling emergence (100%) was recorded in seed invigorated with the both treatments of potassium iodide followed by 97.5 percent in all other treatments as compared to 90% in untreated seeds. Potassium iodide (2 hrs) invigorated seeds showed highest dry matter yield (3.14g per plant) followed by 2.91g per plant recorded in seeds dry dressed with calcium hypochlorite as compared to 1.82g per plant in untreated control. In general, invigorating treatments were found to improve seedling emergence and dry weight over control.

Biochemical mechanism/response of disease resistance

Peroxidase activity : Out of 8 genotypes, IFC-8402, IGFRI-450 and UPC 4200 have shown a significant increase in peroxidase activity after 2 and 4 days of treatment with 0.02% solution of salicylic acid. Six genotypes have shown significant increase of peroxidase activity after four days of treatment (Table 13). Increase of peroxidase activity is one of the criteria of hypersensitive reaction. Since guaicol has been used for the activity measurement it is presumed that genotypes showing higher activity must be having better capacity of lignification as this category of peroxidase is involved in lignin biosynthesis and thereby the tendency of enhanced resistance.

Isozyme pattern : Isozyme patterns of catalase, peroxidase and esterase indicate both qualitative and quantitative change in all eight genotypes of cowpea at different times of interval in both SA treated and untreated plants. The significant decrease in catalase activity as well as reduction in the number of catalase isozyme bands were observed in starch gel. A significant change in esterase isozyme pattern as disappearance of one and appearance of one new band was noticed in UPC 4200 genotype after SA treatment. Similar change was observed in genotype IFC 902.

Table 13: Changes in peroxidase activity after salicylic acid treatment (Activity is expressed in units/mg protein where one unit is change of 0.1 O.D./min)

(a) Two day treatment

Genotypes	Control	Treated	Mean
IFC 8401	48.01	43.91*	45.96
IFC 8402	19.72	40.57*	30.15
IFC 901	28.67	15.95*	22.31
IFC 902	42.95	23.96*	33.46
Bundel 2	21.80	36.29*	29.05
IGFRI 450	27.47	31.39*	29.43
IGFRI 95	68.51	59.63*	64.07
UPC 4200	15.95	35.10*	25.53
Mean	34.14	35.85	
CD at 0.05			
	T= 1.04	G= 2.07	TxG= 2.93

* significant change over control

(b) Four day treatment

Genotypes	Control	Treated	Mean
IFC 8401	45.90	58.15*	52.03
IFC 8402	31.32	51.84*	41.58
IFC 901	20.90	48.27*	34.59
IFC 902	18.20	48.29*	33.25
Bundel 2	33.57	36.11	34.84
IGFRI 450	28.07	45.59*	36.83
IGFRI 95	49.74	44.66	47.20
UPC 4200	27.72	39.15*	33.44
Mean	31.92	46.50	
CD at 0.05			
	T= 2.45	G= 4.88	TxG= 6.90

* Significant change over control

LUCERNE (*Medicago* sp.)

Grouping of germplasm

One hundred twenty two lines selected from different parts of India have been grouped on the basis of following major internode patterns :

- Accelerated
- Uniform
- Retarted
- Irregular

Resistance to weevil pest was also recorded in these lines. The fast growing broad leaved types from Maharashtra, Gujarat and Rajasthan were relatively more susceptible to pest damage than the slow growing lines of the same region.

Karyotypic studies in induced tetraploids of Medicago species

***Medicago littoralis* :** Somatic chromosome number in root tip cells of C_3 generation plants viz. Plant No. C3-7 and C3-9 was 2n = 4x = 32 consisting of 5 pairs of 'A' type, 4 pairs of 'B' type, 6 pairs of 'C' type and 1 pair of 'D' type chromosomes. The length of chromosome varied from 2.78 to 5.1 and 2.91 to 5.31 µm respectively. The total chromatin length was 132.65 µm and 131.12 µm, TF % 41.98 and 40.09 respectively in these induced tetraploids. In plant No. C3-7, 10 pairs were found to be median type and the remaining 6 pairs were submedian type. In plant No. C3-9, 11 pairs were found to be median and 5 pairs were submedian type.

***M. orbicularis* :** The somatic chromosome number in root tip cells of C_4 generation plant was 2n = 4x = 32 consisting of 5 pairs of 'A' type, 4 pairs 'B' type, 6 pairs 'C' type and 1 pair of 'D' type chromosomes of which 11 pairs were median and 5 pairs were submedian. The length of chromosomes varied from 2.85 to 5.65 µm. The total chromatin length was 133.88 µm and TF % was recorded to be 43.25.

***M. rotata* :** The root tip cells of C_4 plant showed 32 chromosomes of which two pairs were 'A' type, 3 pairs 'B' , 7 pairs 'C' and 4 pairs 'D' type while 7 pairs of chromosomes possess submedian primary constiction, the rest 9 pairs were of median type. The shortest chromosome measures 2.5 µm and the longest 6.12 µm. The total chromatin length was 134.5 µm and the TF% was 42.31.

Tissue culture

Callus was successfully induced from various explants *viz*., petiole, hypocotyl, cotyledon, node, leaf and seeds on MS and SH media. The regeneration was achieved from the embryogenic calli on their transfer to the regeneration medium, though at a low frequency. The emerging shoots were differentiated into plantlets exhibiting well developed roots.

Effect of secondary salinisation on physiological characteristics

Three lucerne genotypes RLS-88, T-9 and Anand-2 were raised in pots and irrigated with saline water of different electrical conductivity (EC) 0.8(control), 4, 6, 8, 10 and 12 mmhos cm. Physiological and biochemical observations were carried out

at 30 and 75 days (15 days after first cut) to ascertain the effect of secondary salinisation on these characters.

Carbon exchange rate, stomatal resistance, transpiration rate, stomatal conductance, intercellular CO_2 concentration, relative water content, root length, root-shoot ratio, proline content, water use efficiency, chlorophyll a, chlorophyll b and total chlorophyll were measured. Changes were observed at both the stages of sampling but no consistent pattern was found at 30 DAS. At 75 DAS the relative water content decreased in all the genotypes. At 12 EC, T-9 and Anand-2 showed 15.9% and 14.0% decline respectively over the control whereas RLS-88 showed a 6.0% fall in relative water content (Fig. 2a). Carbon exchange rate decreased at 12 EC in T-9 and RLS-88 whereas Anand-2 maintained more or less similar rates (Table 14). The variation in carbon exchange, however, could not be attributed solely to the stomatal or non stomatal limitation. Root-shoot ratio was maintained in T-9 but increased in RLS-88 and Anand-2 at 10 EC (Fig. 2b). Root length increased with increasing salinity levels in Anand-2 and T-9 to enable the plants to absorb water from deeper layers of the soil (Fig. 2c).

BERSEEM (*Trifolium alexandrinum*)

Germplasm acquisition and evaluation

Seven different *Trifolium* species were raised in 96-97 and data recorded for various morphological attributes (Table 15). Temperate perennial species *viz*. *Trifolium repens* and *T. pratense* survived intense hot summer season of Jhansi.

Twenty one species of genus *Trifolium* (*T. resupinatum, T. vesiculosum, T.*

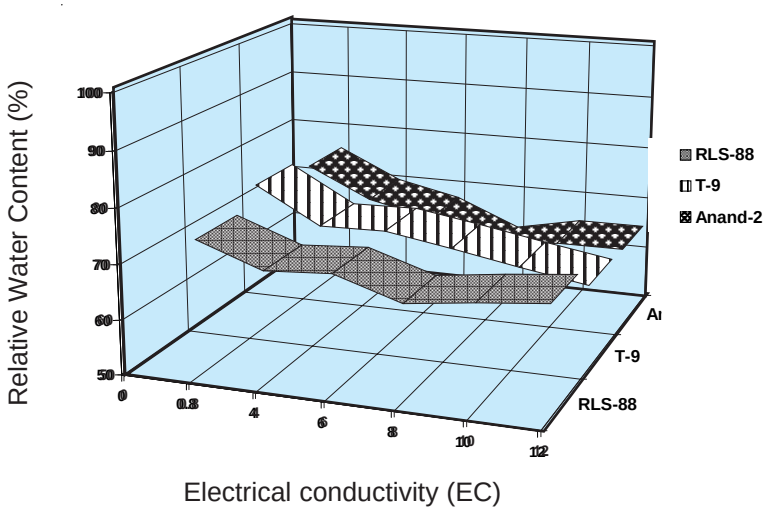


Fig. 2a : Relative water content of lucerne genotypes irrigated with saline water of different electrical conductivity

Table 14 : Photosynthetic characteristics of lucerne genotypes irrigated with different levels of saline water

Treatment (EC)	CER µmol CO_2 $m^{-2}s^{-1}$			Ci µbar			Rs sm^{-1}			CER/Ci		
	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3
0.8	20.17	18.97	19.30	199.9	184.2	179.1	1.03	1.12	1.13	0.101	0.103	0.108
4.0	15.21	19.72	20.18	168.3	186.3	176.7	1.60	0.95	1.34	0.090	0.106	0.114
6.0	18.69	18.92	19.18	170.3	152.0	154.0	1.07	1.43	1.44	0.110	0.124	0.124
8.0	17.42	18.79	20.34	165.8	159.1	157.9	1.33	1.30	1.14	0.105	0.118	0.129
10.0	17.18	19.87	19.28	171.1	141.1	148.0	1.20	1.58	1.43	0.100	0.141	0.130
12.0	14.25	15.61	18.45	137.1	136.1	148.5	2.13	1.93	1.43	0.104	0.115	0.124
CD at 5%		5.84			38.4			0.56				0.041

CER-Carbon Exchange Rate
Ci-Internal CO_2 concentration
Rs-Stomatal resistance
CER/Ci-Carboxylation efficiency
G1- RLS-88
G2- T-9
G3- Anand-2

subterranum, T. michelianum, T. cherleri, T. cernuum, T. glomeratum, T. isthonocarpum, T. incarnatum, T. tembense, T. hirtum, T. alexandrinum, T. retusum, T. nigrescence, T.campestre, T. arvense, T.tomentusum, T. spumosum, T. diffusum, T. augustifolium and T. lappaceum) have been procured from various exotic sources through correspondence and raised for evaluation in 1997-98.

Advancement and stabilization of colchiploid progenies

The colchiploid progenies were raised for advancement of generation and selections made for higher seed producing lines.

Station trial

One station trial comprising 26 diploid and 28 tetraploid lines was conducted dur-

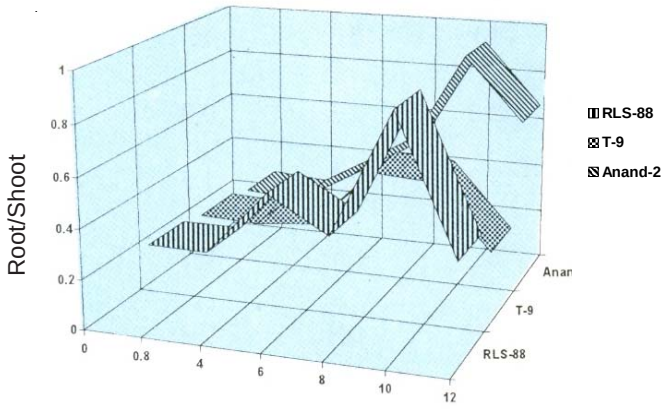


Fig. 2b : Root/shoot ratio of lucerne genotypes irrigated with saline water of different electrical conductivity

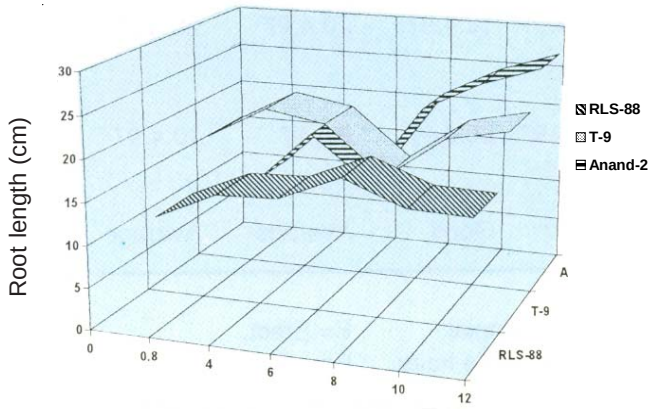


Fig. 2c : Root length of lucerne genotypes irrigated with saline water of different electrical conductivity

Table 15: Morphological characteristics of different *Trifolium* species

Characters	*T.alex-ndrinum*	*T.resu-pinatum*	*T.vesi-culosum*	*T.pra-tense*	*T.sub-terranum*	*T.incar-natum*	*T. repens*
Habit Annual/ Perennial	E A	Pr/E A	Pr A	E P	Pr/runner A	E A	Pr P
Plant height(cm)	55.0	45.1	73.6	63.1	47.8	41.9	35.2
No. of branches	20	15	16	25	25	24	14
No. of nodes	9	7	13	8	16	4	12
Leaf length(cm)	4.3	4.1	2.3	2.5	0.8	3.0	1.4
Petiole length(cm)	2.4	3.8	3.2	2.5	1.5	3.7	7.5
Leaf margin	En	S	S	En	En	En	S
Leaf hairiness	NH	NH	NH	DH	DH	DH	NH
Stipule width(cm)	0.2	0.1	0.6	0.9	0.3	1.3	0.2
Flower size (LxB)(cm)	1.8x1.2	0.8x0.7	3.5x2.5	3.8x2.4	0.8x0.3	5.0x1.8	1.8x1.2
Date of flowering initiation	20.3.97	31.3.97	18.4.97	20.4.97	20.3.97	5.3.97	25.3.97
Date of 50% flowering	10.4.97	15.4.97	26.4.97	5.5.97	10.4.97	30.3.97	10.4.97
Seed set	Good	Good	Good	Average	Average	Good	Poor

A = Annual , P = Perennial, E= Erect, Pr = Prostrate,
NH = Non Hairy, DH = Dense hairy, En = Entire, S = serrate

ing 1996-97 and data recorded for morphological attributes and GFY over the cuts. Analysis of data indicated superior performance of tetraploid lines viz. 1-90 P3-1, 1-90 N1, 5-90 M2, Comp- 5, 64-UP-2, 1-90 A1, 8-90 C2, and diploid lines such as 12/8(17/4-7), 17/11 and 17/19 over Wardan.

All India co-ordinated trial

During 1996-97 IGFRI entries JHTB 96-4 and JHTB 96-5 have ranked first and second in All India Co-ordinated trial and were promoted to Advance varietal trial.

Two new diploid lines JHB 97-1, JHB 97-2 and two tetraploid lines JHTB 97-3 and JHTB 97-4 were entered in All India co-ordinated trial in 1997-98.

Use of bees as pollinator

Italian bees as pollinators have been used in many combinations this year for raising selfed progenies. Many individual plants were selfed in isolation in addition to several plants of one variety using Italian bees as pollinator. The result indicate that role of pollinator is very crucial for seed set. Prevention of bees visit severely hampers seed setting (Table 16).

Tissue culture

Response of four different species to callus induction was tested. *T. alexandrinum* cv Wardan *T. repens* (collection from Palampur), *T. pratense* (Palampur collection) and *T. resupinatum* (Jhansi local collection) gave good response for callus induction and proliferation.

Various plant parts viz. root, shoot, collar, cotytledon, hypocotyl etc. of germinated seedlings were excised and used as explants. Differential response for induction of callus and its proliferation was observed (Table 17). 10-20 days old calli were subcultured for differentiation and/or somatic embryogenesis.

Seeds of *T. alexandrinum* cv. Wardan were germinated to develop axenic cultures and the hypocotyles were used as ex-

Table 16: Seeds set in self and open pollinated flowers of *Trifolium alexandrinum*

Treatment	seeds/inflorescence		% seeds set	
	Range	Mean	Range	Mean
Bees self (Single plant)	3.79 - 22.58	10.72	6.50 - 67.80	44.42
Self without bees (Single plant)	5.56 - 18.50	8.80	5.90 - 30.86	15.00
Bees self one line	5.91 - 53.48	17.29	1.88 - 74.10	27.85
Open pollinated	27.50 - 79.80	53.90	29.80 - 95.10	76.83

plants for callus induction on different culture media. The embryogenic calli were obtained in subsequent subcultures.

LABLAB BEAN *(Lablab purpureus)*

Germplasm evaluation

Two hundred seventy lines of lablab bean sown during Kharif-1996 were left as ratoon for assessing their persistence, yield potential and the degree of tolerance to major diseases and pests under dryland conditions in second year of growth. There was severe incidence of yellow leaf mosaic because of the humid weather and frequent rains during winter (Oct. - Dec.). Thirty eight lines could not survive. Other one hundred thirteen lines lost over 50% of their plant population. Only 17 lines expressed their potential equal or slightly better than Bundel Sem-1 (control) by maintaining their population above 90%. Promising lines include JLP-4, IL-31, IL-836, IL-7/93, AP-1, 30/93, 40/30, 42/93, 96/94, 217/93, 23/93, 43/48, 4/93, 5/93 and cv. High worth.

Fifty-five new accessions of lablab bean obtained from ILCA, Ethiopia , Hilly regions of Andhra Pradesh and the tribal areas of Madhya Pradesh were raised alongwith

Table 17 : Response of various explants of different species of *Trifolium*

Species	Explants	Response
T. alexandrinum		
	root	+,initial few calli
	hypocotyl	+++,compact and friable calli, differntiating into chlorophyllous calli, vigorous growth
	petiole	++, compact, chlorophyllous calli, vigorous growth
	leaf lamina	++, compact calli, friable, chlorophyllous
T. resupinatum		
	root	poor response
	petiole	++, compact calli, green chlorophyllous
	hypocotyl	+++, vigorous growth, green
	leaf lamina	++, compact, green
T. pratense		
	hypocotyl	hyaline callus, slow growth
	root	+, slow growing hyaline callus
T. subterranum		
	root	poor response, very few hyaline callus
	hypocotyl	++, green friable calli
	leaf lamina	++, compact hyaline calli

control for their primary evaluation and maintenance. Majority of the accessions belong to vegetable group and showed poor fodder potential. Wide morphological diversity was recorded in respect to plant, pod, flowering, degree of tolerance to frost and the major diseases. All accessions showed medium to very high degree of susceptibility to frost and yellow leaf mosaic disease. Accessions IL-97-7, IL-97-12, IL-97-281, IL-97-284, IL-97-291, IL-97-292, IL-97-238, IL-97-302 and IL-97-309 have been selected for further evaluation.

Varietal evaluation

Eight dual purpose (fodder cum seed) strains of lablab bean viz, S-27, S-29, S-836, LPS-2, JLP-3, S-13-I and S-33-III alongwith cv. Bundel Sem-1 (control) sown during July, 1996 were left as ratoon for assessing their persistence, yield potential and the degree of tolerance to major diseases and pests during second year of the crop growth. Observations recorded on different growth and yield parameters exhibited that S-27,S-29,S-836 & LPS-2 maintained their population between 73 to 80% as compared to first year.

Mutation breeding

Seeds of the two morphologically distinct cultivars *viz.* Bundel Sem-1 and JLP-3 were treated with six different doses of gamma rays i.e. 10,20, 25, 30, 35 and 40 krad. The irradiated seeds and their respective controls were also treated with 0.1 and 0.2% solution of EMS for 6.0 hr. Treated population showed substantial reduction in seed germination, seedling growth and survival of the plants.

All India coordinated trials

Six promising IGFRI strains are being tested under All India coordinated programme. Based on green and dry matter yield of the fodder LP-27 and LPS-2 have proved their superiority over control (Bundel Sem-1) by a margin of over 11.0 and 9.0% respectively.

RANGE GRASSES

Cenchrus

Germplasm evaluation

Data was recorded on ten attributes pertaining to growth and yield parameters on sixty exotic and nineteen indigenous germplasm lines of *Cenchrus* comprising of 3 species, *viz*. *C. ciliaris, C. setigerus* and *C. biflorus*. (Table 18).

Three hundred and seventy two global accessions of *Cenchrus* species were evaluated for the second year of growth, observations on growth and yield parameters were recorded after each of three successive cuts during 1997 to determine their regenerating potential. The green fodder yield per plant ranged from 105 - 1886 gm after two cuts and 261 - 3229 gm after 3 cuts implying a wide range of variability. Nine accessions *viz*., EC-397327, 397714, 397631, 397497, 397400, 397406, 397404, 397715 and 397628 have been selected for their higher green fodder yield in that order after the third cut.

Elite lines evaluation

Based on the results of preliminary evaluation of *Cenchrus* germplasm during 1996-

97, eleven accessions were found superior in yield. These lines *viz.* EC 397712, 397707, 397692, 397631, 397497, 397490, 397488, 397486, 397434, 397410, 397327 alongwith a check variety, IGFRI-3108 were further evaluated under RCBD. Analysis of variance for dry matter yield and green fodder yield indicated significant differences among these accessions, while five accessions have out performed the check variety for green fodder yield, only two accessions, *viz.* EC 397410 and 397631 had higher dry matter yield over the check.

Hybridization

The F_1 seed of only one hybrid (59 x 347) out of fourteen intraspecific hybrids of *C. ciliaris* has established successfully.

Coordinated trial

Thirteen strains of *C. ciliaris* were evaluated under RCBD for the fourth year. The analysis of variance indicated significant differences for yield. The entries IGFRI-3133, 675 and 8-4-3 have shown high performance in that order for both green and dry fodder yield.

Table 18 : Range of variation, mean and promising accessions for different characters in *Cenchrus*

Sl. No.	Character	Range	Mean	Promising accessions
1.	Plant height (cm)	64.0- 167.3	119.0	IG-97-63, 77, 83, 84, 86, 87 and 90
2.	Tiller number/plant	18.0- 84.0	45.6	IG-97-74, 87, 89, 106, 110, 607 and 750
3.	Leaf number/tiller	8.0- 18.7	12.7	IG-97-70, 82, 83, 90, 102, 687 and 750
4.	Leaf length (cm)	15.0- 40.7	29.6	IG-97-63, 77, 80, 81, 84 85 and IG-96-79
5.	Leaf breadth (cm)	0.30- 1.10	0.73	IG-97-63, 77, 84, 85 105, 111 and 723
6.	Peduncle length (cm)	12.0- 32.3	23.7	IG-97-62, 66, 68, 73, 77 97 and 110
7.	Spike length (cm)	6.0- 15.7	12.7	IG-97-83, 94, 96, 99, 103, 106 and 110
8.	Spike breadth (cm)	0.90- 3.33	2.14	IG-97-69, 72, 96, 103, 104, 106 and IG-96-723
9.	No. of buds/spike	31.0- 245.0	125.3	IG-97-67, 68, 82, 86, 106, 109 and 110
10.	GFY/plant (g)	50.0-1087.0	441.5	IG-97-105, 106, IG-96-78, 80, 84, 89 and 607

Screening for pest resistance

It was observed that 26 out of 372 germplasm lines *viz.* EC-397321, 397322, 397323, 397329, 397333, 397336, 397341, 397348, 397350, 397351, 397355, 397356, 397358, 397359, 397362, 397367, 397429, 397430, 397442, 397444, 397445, 397452, 397490, 397549, 397579 and 397680 are tolerant to the attack of defoliator pests under natural infestations conditions.

Diseases

The 372 lines were screened for leaf blight disease of *Cenchrus*. About 115 lines showed immunity against blight diseases. Forty eight percent lines were resistant. Rest of the lines were moderately resistant to susceptible.

Tissue culture

Calli induced from three genotypes EC 397569, EC 397645 and EC 397563 of *C. ciliaris* were maintained on MS medium with 3 mg/l 2,4-D and 0.5 mg/l BAP. The embryogenic calli raised from subcultures were transferred to suspension cultures in MS broth with the same plant growth regulators. These suspension cultures were maintained for the development of embryogenic cell colonies.

The anthers of two genotypes of *C. ciliaris* cultured on MS medium with 3-6 per cent sucrose and 3-10 mg 2,4-D /l showed very low frequency of callus induction.

Cytology

The chromosome numbers in PMC(s) of *C. ciliaris, C. myosuroides, C. pennisetiformis* and *C. prieurii* were found to be 2n=68, 70, 36 and 34, respectively.

Embryo sac analysis

Screening of *Cenchrus* germplasm for sexuality/apomixis through auxin-induced parthenocarpy test and pistil-clearing technique was conducted on 63 plants from 29 accessions of *C. ciliaris*, 13 plants from 8 accessions of *C. setigerus*, 5 plants from one accession of *C. prieurii* and 10 plants from 3 accessions of *Cenchrus* hybrid.The plants which were indicated to be sexual by auxin-induced parthenocarpy were further screened by pistil-clearing technique. Auxin-induced parthenocarpy indicated the presence of sexuality in all the five plants of *C. prieurii*, one plant of *Cenchrus* hybrid and in two accessions of *C. ciliaris*. Pistil-clearing technique in these putative sexual plants revealed the *C. prieurii* as completely sexual and the *Cenchrus* hybrid plant and two accessions of *C. ciliaris* as facultative apomicts. In *C. echinatus* pistil-clearing technique revealed its complete sexuality.

Dichanthium

Germplasm evaluation

Evaluation of 100 accessions of *Dichanthium - Borthriochloa* complex collected from various parts of the country indicate presence of considerable genetic diversity. Plant height of different accessions ranged from 36-172 cm, Flag leaf blade length from 1.5 -13.1 cm, Flag leaf sheath length from 2.0 - 14.0 cm. Frequency distribution based on various parameters *viz*. plant height, tillering, growth habit,

general appearence, fodder yield (Fig. 3) show the diversity of accessions.

Tissue culture

Embryogenic callus cultures initiated from two accessions of *D. annulatum* were transferred on MS broth with 3 mg 2,4-D /l and 0.5 BAP/l for developing suspension cultures. The suspension cultures were regularly subcultured at one week interval on the same liquid medium for the development of embryogenic cell suspension colonies.

The callus induction from various explants viz., leaf base, seeds, immature inflorescence, immature embryo and nodal segments from the six selected genotypes of *D. annulatum* was successfully carried out on MS, SH and B5 medium with various combinations of plant growth regulators. The regeneration of plantlets was achieved from the callus derived from leaf base, seed and immature inflorescence in all the six genotypes on the regeneration medium with different combinations of growth regulators.

The long term cultures were maintained by monthly subculturing the calli on callus growth medium and assesed for their regeneration potential. The cultures exhibited profuse regeneration potential (89.89%) upto 6 months.

One hundred thirty nine somaclones evaluated for eight morphological and yield traits, exhibited a wide array of variation (Table 19). The spread of newly generated vari-

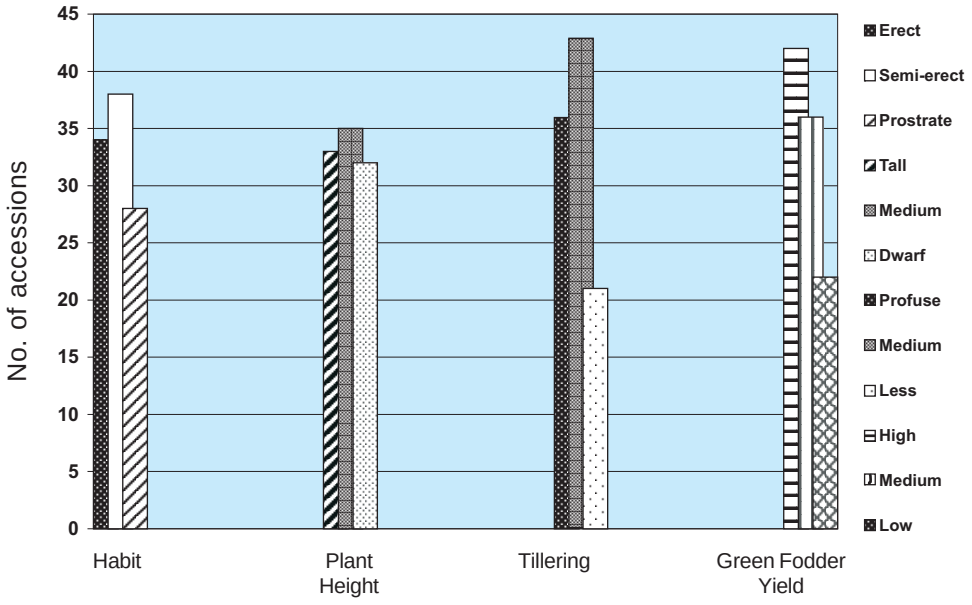


Fig. 3 : Genetic diversity for morphological traits in *Dichanthium* germplasm

Table 19: Range of variation in eight agronomic traits in somaclones of *D. annulatum*

Character	Parent	Somaclones	Desirable somaclones
Plant height (cm)	187.6	111-236	SV 10,24,31,45,49
Tillers/tussock	87.6	106-467	SV 33,27,6,7,73,75
Inflorescence/tiller	1.6	1-9	SV 49,75,1,48,64
Branches/inflorescence	13.5	8.8-17.6	SV 9,61,3,52,53,28,51
Leaf length (cm)	31.5	21.1-38.4	SV 52,56,13,3,17,22
Leaf width (cm)	0.86	0.72-1.10	SV 28,18,19,30,60,75
Internodal length (cm)	7.72	5.8-10.3	SV 27,7,6,75,73,71
Green fodder/tussock (kg)	0.433	0.25-3.50	SV 27,7,9,1,4,10,19

ation was more even in the case of green fodder yield, branches/inflorescence, internode length and tillers/tussock, indicating the possibility of improving these traits using somaclonal variation.

The frequency of apomixis/sexuality was estimated in seven somaclones and their parent by auxin induced parthenogenesis test. The frequency of sexuality ranged from 28% to 47% with five somaclones exhibiting a higher degree of sexuality as compared to the parent.

Ten somaclonal variants of *Dichanthium annulatum*, planted during 1996 were evaluated for growth and yield during their second year of growth. Based on the analysis of yield, SV-27, SV-2, SV-20 and SV-7 have been found to be superior to the check variety Marvel-8.

Sehima nervosum

Germplasm evaluation

Evaluation of twelve accessions for various morphological traits such as plant height, leaf length, leaf width, number of nodes, green fodder yield indicate presence of considerble diversity (Table 20).

Co-ordinated trial

Four entries of Sehima are being maintained at this centre. The evaluation shows that entry IG 9603 performed best (GFY - 678.4 q/ha, DMY 299.06 q/ha) followed by IG 9601 (GFY - 550.6 q/ha , DMY - 273.34 q/ha).

Chrysopogon fulvus

Evaluation of 10 accessions in RBD indicate presence of variation among the

germplasm. The plant height ranged from 128-198 cm, number of nodes from 12-19/ tiller, leaf blade length from 17-54 cm.

Co-ordinated trial

Out of four entries, IG9603 performed best (GFY - 363.36 q/ha, DMY - 181.06 q/ha) followed by IG9601 (GFY - 318.9 q/ha, DMY - 155.9 q/ha).

Entomological evaluation

Accession number 2041,2044, 2045 of *Sehima* were tolerant to the attack of defoliator. In *Chrysopogon*, accession number 2007, 2014, 2014B and 2020 were tolerant to the attack of defoliators.

Guinea grass (*Panicum maximum*)

Coordinated trial

Three promising lines are in second year of perennial trial in All India coordinated trial on Guinea grass.

Evaluation and selection of germplasm

138 germplasm lines including 50 exotic lines and three sexual lines were evaluated for their various morphological attributes. Preliminary evaluation indicate presence of considerable genetic diversity for morphological characters (Fig. 4).

Evaluation for shade tolerance

Ten promising lines in three replication have been grown under *Albizzia amara*. The data recorded this year indicate that five lines (NEHPM-2, LSPM-3, LSPM-blue-2, 59913 and Dhar-PMRS-1/1) can be exploited for fodder cultivation under varying degree of shade in silvipastoral systems. Under shade, these lines show a quantum

Table 20 : Evaluation of selected *Sehima* strains

Accession number	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	No.of Nodes	GFY/ tussock (g)	DMY (%)
2041	124.3	43.0	0.47	12.7	713.89	48.93
2048	109.0	28.0	0.47	12.0	777.22	49.47
2040	99.0	33.5	0.35	10.5	545.00	57.90
2045	116.0	37.3	0.43	13.0	394.44	51.00
2036	81.7	19.3	0.33	10.7	652.78	68.33
2032	84.3	24.6	0.37	11.0	600.00	62.53
2091-1	124.3	30.6	0.37	13.7	755.56	42.87
2044	118.5	31.5	0.35	12.7	737.50	55.85
2061	116.0	40.3	0.33	10.3	1079.40	42.53
2062	78.3	21.3	0.37	11.7	483.33	76.67
Local B	119.0	26.0	0.40	13.0	666.67	53.00
Local A	127.0	29.0	0.40	11.0	450.00	53.20

jump (up to 200-300%) for crude protein content (Fig. 5)

Cytological study

Cytological study on sexual and apomictic lines indicate that there is an increased frequency of laggards (up to 6) and abnormal chromosomal associations in apomictic lines. Two sexual lines were found to be tetraploid exhibiting chromosome complement 2n = 4x = 32. The chromosomal association shows presence of 2-8 quadrivalents per PMC (Plate 1).

Biochemical characterization

Biochemical characterization of various apomictic lines, sexual lines and their progenies from open poly cross nursery indicate presence of considerable genetic variation at the enzymatic level as revealed by starch

Characters :	Ht = Height (cm),	A: 75-120	B: 121-160	C: 161-200
	LL=Leaf length (cm)	A: 18-50	B: 2.0-2.9	
	LW=Leaf width (cm)	A: 1-1.9	B: 2.0-2.9	
	PL=Panicle length (cm)	A: 22-50	B: 51-88	
	LS=Leaf surface	A: glaborous	B: dense hairy	C: less hairy
		D: medium		
	LSS=Leaf sheath surface	A: glaborous	B: dense hairy	C: less hairy
		D: medium		
	FCL=Flower colour (glaborous + 1 bract)		A: purple(P), purple(P), green(g)	
			B: ggg	C: pgg D: ppp
	Ftx=Flower texture	A: glaborous	B: hairy	
	Br=Branching	A: less profused		B: medium C: high
	F-Int=Density of flowers	A: low	B: medium	C: high
	Matur=Maturity	A: early	B: medium	C: late

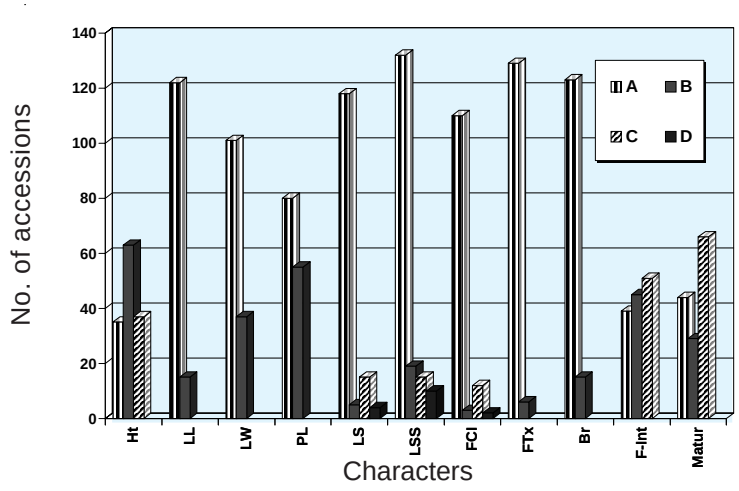


Fig. 4 : Genetic diversity for morphological characters in *Panicum maximum* germplasm

gel electrophoresis. Zymogram pattern of six isozymes *viz.* peroxidase, esterase, acid phosphatase, alkaline phosphatase, superoxide dismutase, Aspartate amino transferase indicate introgression of variant alleles from donor parents in some of the progenies obtained from the sexual lines.

Intervarietal crosses

Intervarietal crosses were made using the sexual lines as female and five selected apomictic lines as pollen parent.

RANGE LEGUMES

During the reporting period 643 new accessions of range/cultivated legumes were added into the existing gene pool which comprises mainly of *Stylosanthes* sps (343), *Centrosema pubescence* (88), *Desmenthus virgatus* (58), *Lablab purpureus* (44), *Trifolium species* (36).

Stylosanthes species

Diverse accessions of Stylosanthes species were evaluated in two sets of experiments. Firstly, 64 different strains of *S. hamata* (53), *S. guianensis* (4), *S. scabra* (2), *S. viscosa* (2) and one each of *S. macrocephala, S. graclis* were evaluated for various growth parameters. In *S. hamata* days of flowering varied between 58-80 days and IL-25, 23 and 18 were found early types which flowered in 58-65 days. In the same species plant height (cm) varied between 45-142 cm and IL-22 was dwarf type with 45 cm plant height alongwith spreading turf type growth behaviour. Most of the

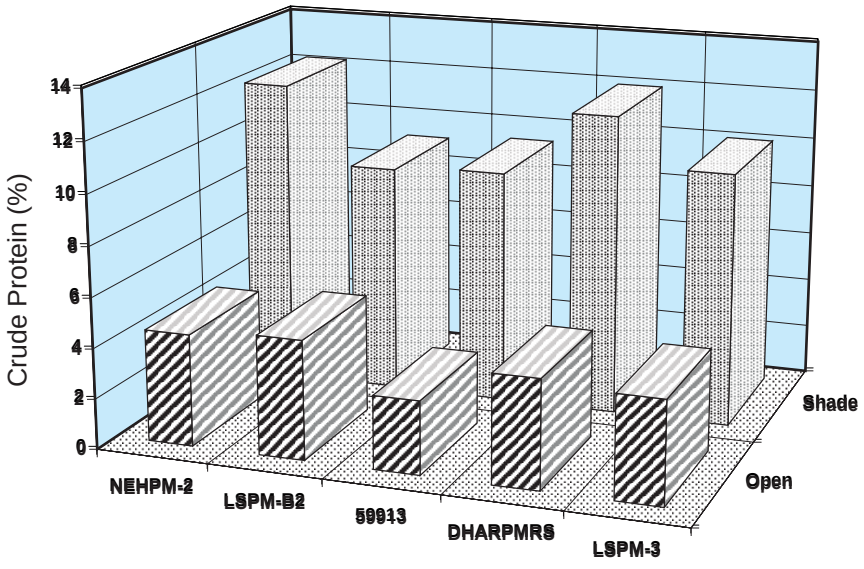


Fig. 5 : Crude protein content (%) in Guinea lines under open and shade conditions

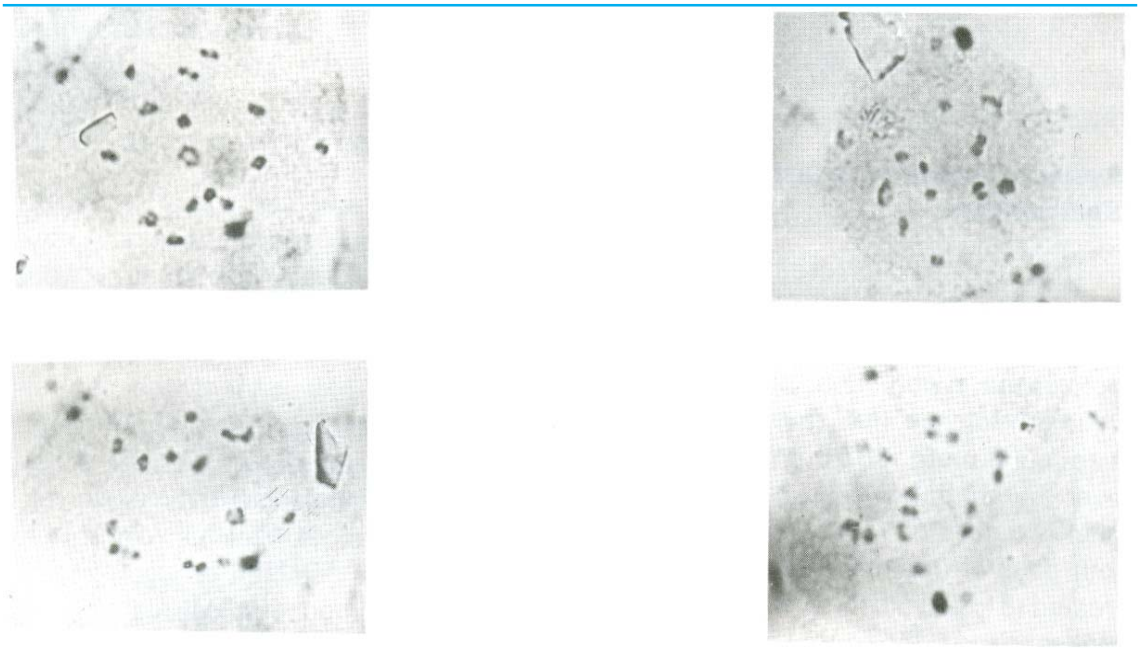


Plate 1 : Chromosomal association at diakinesis in sexual lines of *Panicum maximum*

accessions were having semi-erect growth habit while few genotypes *viz.* IL-26 and 18 showed erect habit. Accessions IL-25, 17 and 19 were found most promising for profused branching. On the basis of yield/plant (g) accessions IL.22 (545 g) gave superior yield for green fodder followed by IL.19 and 25 with 475 and 460 g respectively.

In another set, 363 lines of various species of *Stylosanthes* obtained from ILCA, Ethiopia were grown in a single row trial. Preliminary evaluation indicated a wide range of variation in growth habits such as spreading, erect and semi-erect types. Days to flowering ranged between 48-87 days, plant height (20.0 - 70.0 cm) and green fodder yield per plant varied between 222-285 g.

The chemical analysis done for phenol content in selected strains showed wide range of variation (0.095-0.38%) with IL-507 recorded minimum (0.095%).

Pathological aspect

Bacterial blight (*Xanthomonas campestris* pv. *vignicola*) and root rot (*Rhizoctonia bataticola* and *R. solani*) in field bean were observed during *kharif* season.

Four hundred nine lines of stylosanthes belonging to five species viz *S. hamata, S. guainensis, S. viscosa, S. humilis* and *S. scabra* were observed for occurrence and reaction of diseases. In the collection, three diseases namely stem and inflorescence blight (*Botrytus cinerea* and *Rhizoctonia solani*), leafspots caused by *Cercospora* sps. and Anthracnose caused by *Collectotrichum gloesporioides* were observed. The lines IL97-607, IL-97-519, IL97-591, IL97-

616, IL-97-612, IL97-615, IL97-584, IL97-523, IL97-452, IL97-497, IL97-507 were resistant against anthracnose.

Systemic Acquired Resistance (SAR) in *Stylosanthes*

The 0.02% solution of salicylic acid was sprayed on *Stylosanthes hamata* and *S. scabra* to study the role of the enzyme peroxidase in imparting the systemic acquired resistance. In *S. hamata* the activity was found more (68.76 units/mg protein) over the control (37.76 units/mg protein) after two days of treatment whereas after four days of treatment the activity of the treated (81.80 units/mg protein) plant samples reaches to the control (91.35 units/mg protein). On the other hand *S. scabra* showed increase in the activity over the control plants on both days of observation.

The reduction of Polyphenol oxidase (PPO) activity using chlorogenic acid as the substrate was found to be very less in both species. Nevertheless, *S. scabra* showed higher activity than that of *S. hamata*.

Siratro (*Macroptelium atropurepureum*)

Germplasm evaluation

38 accessions including 20 exotic lines were evaluated for genetic variability and observations were recorded for various fodder yielding traits.

Relationship between plant characters: The association analysis indicated that green weight per plant was highly significant and positively correlated with plant height (0.762**), number of secondary branches (0.693**), average number of leaves/plant (0.664**), number of nodes (0.548**) and dry weight/ plant (0.932**).

Comparision and classification of accessions: Principal component and non-hierarchial Euclidean cluster analysis were used to compare the genotypes. Entire genepool was classified into eight broad groups. Group III was the largest consisting of 12 genotypes while group VIII comprised a solitary genotype. Further, principal component yielded into ten eigen vectors and eigen roots. Maximum eigen roots value 4.47 was obtained by eigen vector-1. First four components calculated using standard variables accounted for 44.71%, 15.77%, 10.52% and 9.11% of the variation respectively (total 80.11%). The average intra-cluster distances ranged between 0.0 - 1.914. The maximum inter-cluster distance (7.535) was found between cluster I and VIII followed by VI and VII (6.451). The observed distances showed the genetic diversity in accessions and their linkages with respect to one another. Regarding relationship of accessions to place of origin, the clustering pattern showed that genotypes of heterogenous origin were grouped in the same cluster and there is no parallelism between genetic and geographical diversity.

Potential genetic donoar for different attributes : The potential genetic donor screened from cluster mean for the attributes indicated that for maximum plant height, number of secondary branches, number of nodes, green and dry wt/plant

superior strains were grouped in cluster VI having genotype IL-150 and 156. Further, group IV have accession with maximum leaves/plant and internode length. However, green types viz. IL-142, 155, 10 and 11 in cluster V were early in flowering.

Pathological aspects

Twenty two accessions of Siratro were screened against various diseases. Among them foliar blight (*Rhizoctonia solanii)* was more prominent. Seven lines showed resistance against foliar blight viz. 96-3, 5, 97-2, 5, 8, 14 and 16.

Clitoria ternatea

Five IGFRI entries were evaluated during *Kharif* 1997 under advance varietal trial of AICRP(FC). IGFRI-23-1, 173-1, 7-3 were found superior over other genotypes for green fodder yield 212.0, 205.6 and 194.3 q/h as well as dry fodder yield 45.8, 44.4 and 42.5 q/h respectively.

TREES AND SHRUBS

Micropropagation of forage tree species

Axillary and apical shoot buds of *Anogeissus pendula, A. latifolia* and *Hardwickia binata* and the axillary buds of a hybrid tree of *Leucaena diversifolia x L. leucocephala* were cultured for micropropagation. Induction of multiple shoot buds was achieved in *A. pendula* and *Leucaena* hybrid. The shoot bud multiplication in *A. latifolia* and *H. binata* and the induction of roots of multiplied shoot buds of *A. pendula* and *Leucaena* hybrid are in progress.

Quality evaluation of Trispecific Hybrid of *Cajanus cajan* x (*Atylosia albicans* x *Atylosia scarabaeoides*)

Seven selected plants revealed crude protein content which ranged from 21.50 to 24.73 %. The hybrid plant F7-4 possessed highest CP content. The NDF ranged from 52.86 to 58.57 %, ADF from 40.00 to 50.05%, Lignin from 8.57 to 12.85 %, Hemicellulose from 8.57 to 15.71 %, cellulose from 18.57 to 22.86 %, silica from 8.57 to 14.28 % . The nutritionally superior hybrids have been selected.

Physiological studies under light stress

Three range grasses *Cenchrus ciliaris, Dichanthium annulatum and Panicum antidotale* and two range legumes Stylosanthes hamata, *Macroptelium atropurpureum* were grown under four different light intensities *viz.* 100% (control), 75%, 50% and 25% in field. The observations on photosynthetic pigments and soluble protein accumulation were recorded at 50% flowering stage during the second year of establishment of the crop.

Photosynthetic pigment accumulation

In all the grasses an increasing tendency was observed in the accumulation of photosynthetic pigment (Chl b) with respect to the decreasing light intensities (Fig. 6)**.** The same trend was observed for chl a accumulation in *Dichanthium annulatum* (Fig. 7). In *C. ciliaris and P.antidotale* high Chl b was recorded under 50% light intensity. Among the range legumes, *S. hamata* showed an increase over the control but the pigment accumulation was at par in all the

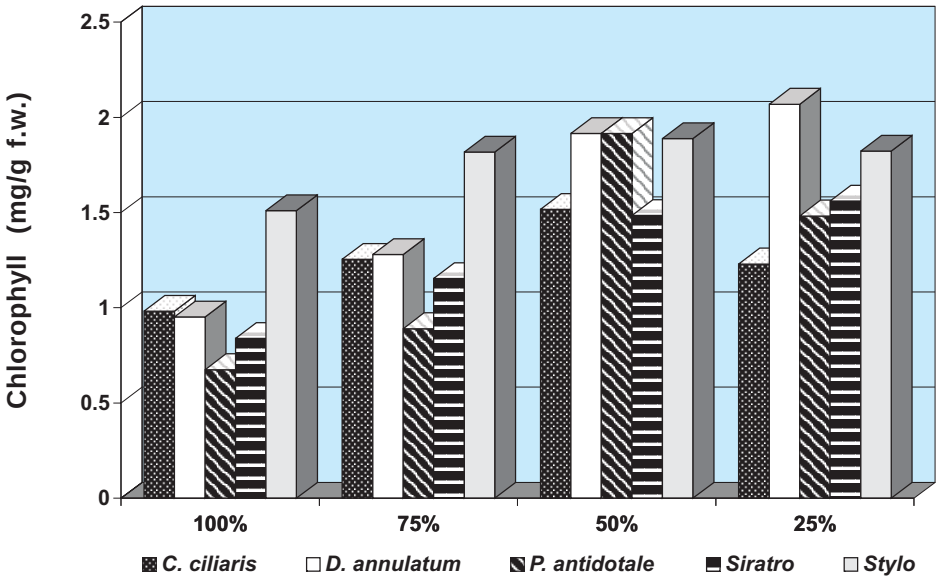


Fig. 6 : Chlorophyll b content under different light intensities

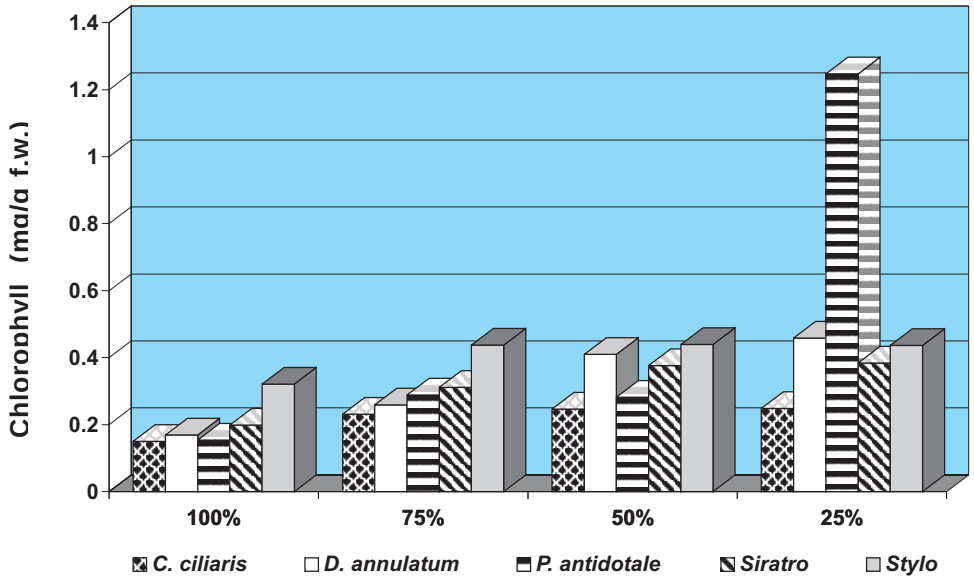


Fig. 7 : Chlorophyll a content under different light intensities

three light regimes i.e. 75%, 50% and 25%. However, *M. atropurpureum* showed an increasing tendency in case of Chl b accumulation. The higher accumulation of Chl b indicated the increased light absorption which may be an adaptation to the shading environment.

Soluble protein accumulation

Among the grasses *C.ciliaris* leaf showed higher accumulation of soluble protein content with respect to the decreasing light intensity which indicates its intrinsic character towards shade adaptation (Table 21). This is expected to improve the quality of fodder under low light stress. However, the soluble protein in stem was at par in all the four light intensities.The grasses *D. annulatum* and *P. antidotale* and both the range legumes showed a declining trend in the accumulation of soluble protein content in leaf with respect to the decreasing light intensities, but more reduction in protein accumulation was observed in case of range legumes.

INSECT POPULATION DYNAMICS

Effect of herbicides on the population of soil microarthropods

Mite population was not affected significantly as a result of soil application of herbicides (in recommended doses) *viz.* atrazine (@ 0.50/0.75 kg a.i./ha) and alachlor (@ 2.0 kg a.i./ha) on crops *viz.* bajra, sorghum and cowpea, respectively.

In bajra and sorghum significantly higher population built up of mites was recorded at the time of harvest. Highest population was recorded in bajra. The mite population consistently increased from the time of sowing to harvest of crops.

In cowpea also significantly higher population built up of mites was recorded at the time of harvest, showing a trend of increase

Table 21 : Soluble protein content in grasses and legumes under light stress

	Soluble protein in mg g^{-1} f.w.							
	LEAF				STEM			
Range grasses	**T_1**	**T_2**	**T_3**	**T_4**	**T_1**	**T_2**	**T_3**	**T_4**
C. ciliaris	16.4	16.9	20.5	21.0	4.0	4.1	4.6	4.2
D. annulatum	23.9	22.2	18.2	17.7	3.2	3.3	3.1	3.0
P.antidotale	25.6	14.6	19.0	17.7	4.9	4.0	2.6	3.9
Range legumes								
Siratro	39.7	34.5	32.7	28.5	16.5	16.3	18.8	19.3
Stylo	36.0	10.1	24.7	23.9	21.6	20.0	16.0	14.9

T_1 -100% (Control), T_2-75%, T_3-50% and T_4-25% Light intensity

from the time of sowing to harvest of crop. However, the population built up in this crop was low when compared to bajra and sorghum (Fig. 8).

Effect of soil amendments/fertilizer treatments on the population of soil microarthropods

In sorghum, higher population built up of Collembola and mites was recorded in FYM treatment. It was followed by the other treatments viz. application of grass litter, phosphate fixing bio-fertilizer, leucaena leaf, Neem cake and NPK (Fig. 9). Also, significant increase in population built up of collembola and mites was observed from sowing to harvest season of sorghum.

PREDACIOUS NEMATODES

Survey and taxonomy

Predacious nematodes constitutes 2 to 10% of the total nematodes in the 63% of the total number of samples collected from various forage crops and grasslands, suggesting its important role in controlling plant-parasitic nematodes. Maximum number of predacious nematodes were found in leguminous forage crops (83%) and generally associated with high organic matter contents. Following predacious nematodes were identified : *Mylonchulus contractus, M. dentatus, M. subsimilus, M. minor, M. sarmini, Iotonchus monhystera, I. jairi, I. indicus, Monnchus aquaticus and Miconchus digiturus.* The occurrence and distribution of these nematodes are : Mylonchulus sp. Relative Frequency = 90, Relative Abundance = 80, Relative Density = 10, Dominance Value Index = 60, Iotonchus sp. RF = 70; RA = 56, RD = 5, DVI = 50/ Mononchus sp. RF = 30, RA = 10, RD = 2, DVI = 14.

In vitro studies of predation by *I. monhystera*

The preference of prey species are *Meloidogyne larvae, Pratylenchus zeae, Tylenchorhynchus vulgaris*. Predation rates were 80 Meloidogyne larvae, 60 P. zeae, 40 *T. vulgaris* within 24 hours in 2% water-agar. In 1% and 4% water-agar predation rates were less. It indicates that in highly water logged and in dry soil predacious activity might be slowed.

Culture of predacious nematodes

Rates of multiplication of both the predacious nematodes *M. minor* and *I. monhystera* were higher in water-agar supported with 0.01% liver extract and also in soil supported with 10% (v/v) FYM or in 10% (v/v) goat manure.

Pot experiment

In the soil amended with dry leaves of leucaena (@ 2g/kg soil) inoculated with 200 predacious nematode (*I. monhystera*) + 2000 larvae of *M. incognita* sown with cowpea reduced (86%) the infestation of *M. incognita* on cowpea and increased the plant weight. In another experiment similar results (75% reduction in *P. zeae* infestation) were also observed in maize.

Management of insect pests in *Sehima - Heteropogon* grassland

Minimum leaf damage by grasshoppers and highest forage yield was observed with

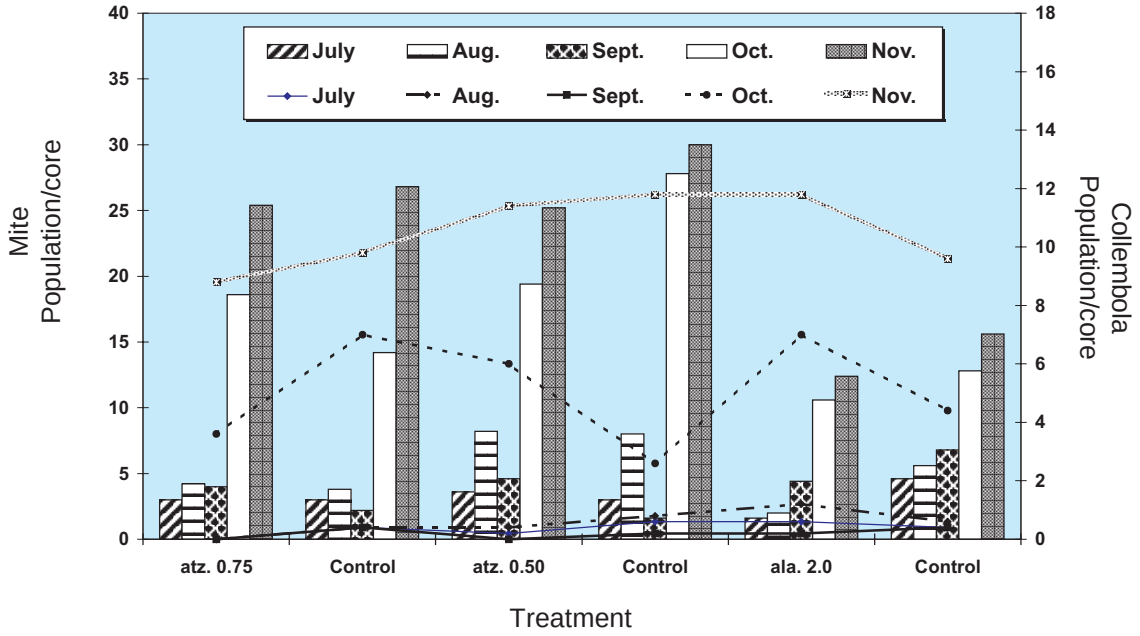


Fig. 8 : Effect of Herbicides on soil Microarthropod

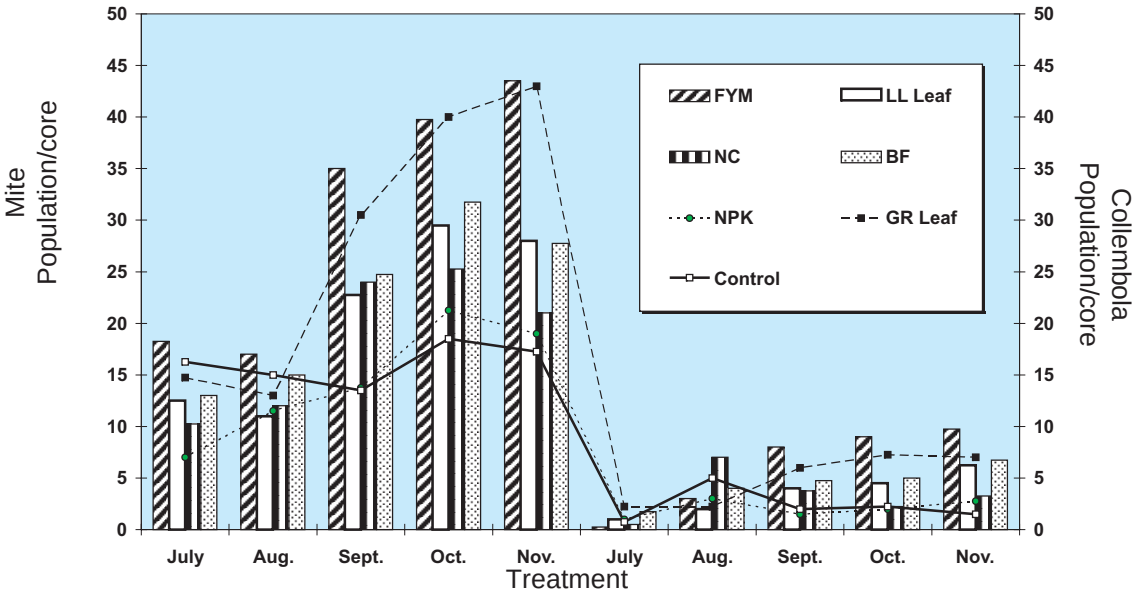


Fig. 9 : Effect of fertilizers on soil Microarthropod in sorghum

the treatment of endosulfan(0.075%, control) followed by Achook, Suneem, Jawan and Bioneem and showed an increase of 2.4, 1.55,1.38,1.26 and 1.20 t/ha respectively of green forage yield over untreated plot.

PESTICIDE RESIDUE ANALYSIS

Sorghum (cv. M.P. Chari) was sown in randomised block design and Endosulfan (Thiodan 35 EC) was sprayed two times, one at 40 DAS and the second at 55 DAS, at the recommended dose of 0.07% (500 g a.i./ha). Initial deposits and subsequent dissipation of endosulfan isomers in sorghum leaves was measured (Table 22).

The rate of dissipation of endosulfan residues followed first order kinetics and the regression equation was Y = 3.312-0.08 X. The residue half-life (T1/2) and safe waiting period (TMRL) based on MRL value of 2 ppm were calculated as 3.76 days and 14.03 days respectively.

INTEGRATED PEST MANAGEMENT

The Cowpea + Sorghum crop was sown in the *Kharif* season of 1996, followed by Berseem + Japan sarson in *Rabi* and Cowpea + Maize in summer. Each study was combination of three variables: two soil treatments (burning of crop residues and incorporation of neem cake @ 15q/ha) with an untreated control; two seed treatments (carbofuran 1% w/w + bavistin 0.2% + thiram 0.25% and *Trichoderma harzianum* + carbofuran 1% w/w) with untreated control; two bio-pesticides (Berliner, a commercial preparation of *Bacillus thuringiensis* @ 0.84 Kg/ha and neem seed kernal extract @3% applied at 45 days crop in cowpea, maize and sorghum and 15 days after first cut in berseem) with an untreated control.

In cowpea the soil treatments showed significant differences for disease incidence

Table 22 : Residues and dissipation of endosulfan isomers in sorghum leaves

Spraying	Sampling Days	Endosulfan isomer		isomers isomer		Total Endosulfan (µg/g)	Dissipation (%)
First	0 (1 hr)	10.59	0.69	13.05	0.80	23.64	-
	15	0.77	0.08	1.12	0.09	1.89	92.00
Second	0 (1 hr)	14.06	1.54	12.46	0.92	26.52	-
	3	6.34	0.45	5.61	0.29	11.95	54.94
	7	1.87	0.27	2.26	0.33	4.13	84.42
	15	0.55	0.10	0.71	0.10	1.26	95.24
	25	0.09	0.01	0.14	0.01	0.23	99.13

* Average of three replicates.

mainly due to supression of pathogens by neem cake (Table 23). The seed treatment with carbofuran+bavistin+thiram suppressed leafhoppers and diseases. The effect of sprays was not significant for disease incidence. None of the interactions between soil, seed and spray treatments were significant. In sorghum the disease incidence was maximum in untreated plots and minimum in plots treated with neem cake and seed treatment with carbofuran + bavistin + thiram. Berseem had significant differences for root and stem rot disease in soil and seed treatments. These can be attributed to the burning of crop residues and residual effect of neem cake incorporation

Table 23: Influence of soil, seed and spray treatments on insect damage disease incidence and green fodder yield

Treatments	SEASON					Total yield t/ha.
	Kharif		*Rabi*		Summer	
	Cowpea Insect damage (%)	Berseem Disease incidence (%)	Cowpea Disease incidence (%)	Disease incidence (%)	Insect damage (%)	
Soil Treatment (S)						
1. Burning	13.87	14.63	9.13	8.46	5.29	166.63
2. Neem Cake	14.24	5.45	6.73	5.00	5.15	176.34
3. Untreated	14.27	25.07	20.44	23.69	5.89	159.96
Seed Treatment (D)						
1. Carbofuron + Bevistine + Thiram	14.31	9.85	9.01	11.54	5.48	166.58
2. Carbofuran + Trichoderma	13.85	8.70	7.19	4.93	5.08	173.24
3- Untreated	14.22	26.60	20.10	20.68	5.78	163.11
Sprays (P)						
1. Berliner (B. Thringiensis)	10.55	9.89	8.34	10.36	4.55	170.23
2. Neem Seed Extract	11.01	13.14	2.04	3.18	3.98	180.56
3. Untreated	20.82	22.12	25.91	23.61	7.80	152.15
Significance (P = 0.05)						
S	NS	*	*	*	NS	*
D	NS	*	*	*	NS	*
O	*	*	*	*	*	*
Interactions	SXDXP	SXD,DXP	SXD,DXP			XDXP,SXD

in soil. Seed treatment with carbofuran + bavistin + thiram had less disease incidence as compared to carbofuran + *Trichoderma*. In summer season the cowpea crop suffered less pest damage as compared to *Kharif* season, however the treatment effects were same as in *Rabi.* The pest incidence was not significant in maize crop.

Total green yield obtained was highest in soil amendment with neem cake followed by burning. In berseem the seed treatments were at par with non-significant differences. The soil amendment with neem cake could reduce the pathogens. Similar situation exist in cowpea but here the spray increased the yield significantly as compared to berseem because in cowpea the foliage insect-pest damage was higher. The combination of soil treatment with neem cake followed by seed treatment with carbofuran+bavistin+thiram produced highest average green fodder yield of 187.61 t/ha/year which is an increase of 18% over untreated control.

The experiment conducted for the third year in *Kharif* season indicated main soil treatments, burning and addition of neem cake influenced the disease incidences in cowpea and sorghum but had no effect on insect incidences in cowpea. The seed treatment with carbofuran + *Trichoderma* along with incorporation of neem cake and neem seed kernal extract spray had lowest mean population of leafhoppers (3.26/plant) and defoliators damage (5.83%) as compared to highest in control (9.45/plant) and 26.33%) respectively. The total grean fodder yield fo cowpea + sorghum was highest (30.83 t/ha) in soil amendment with neem cake, seed treatment with carbofuran+bavistin+thiram and spray of neem seed kernal extract as compared to lowest (23.50 t/ha) in untreated.

3.2 CROP PRODUCTION

FORAGE PRODUCTION SYSTEM UNDER IRRIGATED CONDITIONS

Cultural Management and Fertilizer Use

Organic v/s inorganic fertilizers

Four crop sequences (guinea grass + cowpea-berseem, fodder sorghum-berseem, maize + cowpea - berseem and maize (grain) - wheat) were evaluated with four sources of nutrients (100% through inorganic, 100% through FYM, 50% each through FYM and inorganic source and control). The soil of the experimental plot was *Parwa* (sandy loam) containing 0.22% organic carbon, 175, 10 and 152 kg ha^{-1} available N, P and K respectively alongwith 13 ppm of available S. For the purpose of comparison crop yields were converted in to berseem fodder equivalent yields. Guinea grass + Cowpea - berseem sequence gave maximum berseem equivalent yield (1085.3 q ha^{-1}) which was significantly higher than sorghum - berseem (1060.4 q ha^{-1}), maize + cowpea - wheat (655.6 q ha^{-1}) and maize (grain) - wheat (638.9 q ha^{-1}). Among all the crops included in the cropping sequences, berseem proved to be the most productive crop (793.2 q ha^{-1}) followed by wheat (519.7 q ha^{-1}) and guinea grass (382.1 q ha^{-1}) in terms of berseem equivalent yield. The grain crop of maize was damaged due to biotic interference and hence the yield was very poor. Crop fertilized with inorganic source of nutrients produced significantly higher berseem equivalent yield of 938.8 q ha^{-1}. This was followed by combined application of organic and inorganic sources of nutrients which produced berseem equivalent yield of 901.3 q ha^{-1}. Berseem equivalent yield from the plots fertilized with organic source and unfertilized plot were 837.7 and 728 q ha^{-1}, respectively.

Interaction of nutrient source and crops was not significant during *kharif* season, while it was significant during *rabi* season. Berseem in fodder sorghum - berseem sequence with organic source (FYM) produced maximum yield (918 q ha^{-1}). This was followed by the same crop under a combination of organic and inorganic source (891 q ha^{-1}), wheat on the other hand recorded almost similar berseem equivalent yields with inorganic (671.4 q ha^{-1}) and a combination of inorganic and organic sources (668.9 q ha^{-1}) which was significantly higher than that obtained under organic sources of manuring (421.5 q ha^{-1}) and unfertilized plot (349.9 q ha^{-1}).

Plots fertilized with 100% organic source of nutrient improved soil fertility in terms of available N (206 kg ha^{-1}), P (12.08 kg ha^{-1}), K (204.5 kg ha^{-1}), S (17.8 ppm) and organic carbon (0.31%) as compared to 50% through organic and 50% inorganic source as well as 100% inorganic fertilization.

Varietal evaluation of sorghum

During second year of experimentation,

treatments consisting of three varieties (HC-171, JS-10 and HD-15), three dates of sowing (beginning, mid and end of July) and three levels of nitrogen (40, 80 and 120 kg ha^{-1}) were compared in partial confounding design with two replications. The results revealed that the variety HD-15 produced significantly higher green and dry forage (400.5 and 77.5 q ha^{-1} respectively) which was 13.8% higher over JS-10 (351.9 q green fodder ha^{-1}) and 28.5% higher over check i.e. HC-171 (311.6 q green fodder ha^{-1}). Crops sown in the beginning of July produced significantly higher green and dry forage yields (457.9 and 90.6 q ha^{-1}, respectively) over other dates of sowing. The yields obtained under 120 kg and 80 kg N ha^{-1} were almost equal but significantly higher (381.5 of green fodder and 74.4 q ha^{-1} dry matter) over 40 kg N ha^{-1}. (313.4 green and 60.6 q ha^{-1} dry). Significant interaction was observed between varieties and date of sowing, which indicated that variety HD-15 performed better when sown in the beginning of July.

N and P management in grass + legumes

The treatments consisted of three grass species i.e. setaria (*Setaria sphacelata*) cv. Nandi (C1), guinea (*Panicum maximum* Jacq.) cv. Gutton (C2) and hybrid napier (*Pennisetum purpureum x P. typhoides*) cv. IGFRI No. 6 (C3); two fertilizer levels, *i.e.,* 100% (F1) and 75% (F2) of the recommended dose of fertilizers and three timings of nutrient application (nitrogen in case of perennial grasses and phosphorus in berseem), *i.e.,*full dose of nutrient just after cut (T1), 75% just after cut + 25% 20 days before the next cut (T2) and 50% just after cut + 50% just before next cut (T3) were evaluated. The grass species and fertilizer levels were allocated to main plots whereas, time of nutrient application to sub plots and replicated thrice in split plot design.

In the first year hybrid napier produced maximum tonnage (32.4 t green and 6.26 t dry matter ha^{-1}) which was significantly higher than guinea grass (29.7 t green and 5.60 t ha^{-1} dry matter) and setaria (23.8 t green and 4.76 t ha^{-1} dry matter).

Application of 75% of recommended dose of fertilizer (F2) produced 27.7 t green and 5.73 t dry matter ha^{-1} which was 6.5 and 5% lower than 100% recommended dose (F1). As regards time of fertilizer application, application of 75% nitrogen requirement just after cut and remaining 25%, 20 days before next cut (T2) produced significantly higher yield (298.7 t green and 5.83 t dry matter ha^{-1}) over other treatments which were at par among themselves. The yield obtained with 75% of recommended dose of fertilizers applied as 75% just after cut and 25% at 20 days before next cut was at par with that of 100% of recommended dose of fertilizers applied just after cut.

Nutrient Management Studies

Zn & P nutrition in lucerne-bajra

A pot experiment comprising 4 levels each of Zn (0,10,20 & 30 ppm) and P_2O_5 (0, 20, 40 & 60 ppm) under two types of soil (red & black) was conducted during second year of experimentation on lucerne crop and its residual effect was assessed on bajra crop.

It was found that forage production of lucerne increased markedly upto 20 ppm of Zn and 40 ppm of P_2O_5. The increase beyond these levels was not well marked. However the magnitude of response was more in black soils as compared to red soils. The contents of N,P,K & S and up-take of these nutrients increased appreciably upto 20 ppm of Zn & 40 ppm of P_2O_5. Further it was noted that after harvest of lucerne crop, the availability of N,K & S in soil was increased with 20 ppm of Zn and availability of the same nutrients including P in soil with 40 ppm $P_2O_5$was also increased.

The residual effect of treatments applied to lucerne was evaluated in terms of bajra forage production and it was noted that yield increased with increasing levels of Zn & P_2O_5 under both soil types, however it was more in black soil than red soil. After harvest of bajra crop the soil was analysed for micro-nutrients (Zn, Cu, Mn & Fe) and it was found that availability of Zn increased under all the treatment combinations (1.55-3.56 ppm) over control (0.76 ppm).

Zn & P nutrition in cowpea-oats

A field experiment comprising of 4 levels each of Zn (0, 10, 20 & 30 kg ha^{-1}) and P_2O_5 (0, 30, 60 & 90 kg ha^{-1}) was conducted on cowpea and then residual effect was assessed on succeeding crop of oats. The soil of the experiment was *Parwa* which was low in organic carbon and available N&S, medium in available K and deficient in available P (3.2 ppm) and Zn (0.22 ppm).

Application of Zn @ 10 kg ha^{-1} resulted in maximum forage production of cowpea. Further it was noted that P application increased the yield as well as uptake of N,P,K & S upto 60 kg P_2O_5 ha^{-1}. It is interesting to note that combined application of 20 kg Zn and 60 kg P_2O_5 ha^{-1} gave the highest forage production and crude protein content over other treatment combinations. After harvest of cowpea, availability of nutrients (N,P,K & S) in soil increased with 20 kg Zn and 60 kg P_2O_5 ha^{-1}.

A pot experiment consisting of 4 levels of Zn (0, 5, 10 & 15 ppm) and 4 levels of P_2O_5 (0, 15, 30 & 45 ppm) was also conducted under 2 types of soil *Rakar* & *Parwa* being deficient in both available P & Zn status.

Forage production increased with increase in the levels of Zn & P_2O_5 upto 10 ppm of Zn and 45 ppm of P_2O_5. However, maximum forage production was recorded when 10 ppm Zn was applied along with 30 ppm P_2O_5 in both the soils. It is interesting to note that after harvest of cowpea the availability of N,P,K & S in soils increased with 10 ppm of Zn and 30 ppm of P_2O_5.

Soil S test crop response

A field study was undertaken during *kharif* season with four levels of sulphur (0, 20, 40 & 60 kg S ha^{-1}), three soil types {low (<10 ppm), medium (11-20 ppm) and high (>20 ppm)} and two crops(sorghum pure and sorghum + cowpea) in a split plot design. The results indicated that the fodder yield of sorghum pure and sorghum + cowpea increased with increasing levels of S application upto 60 kg ha^{-1}, the magnitude of increase being more in low S soils

particularly in case of sorghum + cowpea. Forage yields of sorghum and sorghum + cowpea obtained with 40 kg S ha^{-1} in low S soils were more or less similar to the yields with 20 kg S ha^{-1} in medium and high S soils. The maximum responses of green and dry fodder in kg kg^{-1} S at 20, 40 & 60 kg S ha^{-1} were 183 and 36, 133 and 30 & 104 and 20 in low; 112 and 33, 78 and 30 & 76 and 17 in medium and 82 and 27, 71 and 17 & 56 and 13 in high S soils in case of sorghum + cowpea, respectively. On the basis of mean data the responses to added S over control (no S) in low, medium and high S soils were 14, 8 & 6 per cent for green and 15, 11 & 8 per cent for dry fodder of sorghum + cowpea as well as 11, 6 & 4 per cent for green and 11, 8 & 5 per cent for dry fodder of sorghum pure, respectively.

Sulphur uptake improved with all S levels i.e. 20, 40 & 60 kg ha^{-1} over control by 47, 81 & 99 per cent in low; 25, 37 & 40 per cent in medium and 15, 32 & 33 per cent in high S soils in case of sorghum pure and 55, 91 & 116 per cent in low; 38, 47 & 64 per cent in medium and 18, 35 & 42 per cent in high S soils in case of sorghum + cowpea, respectively. The N : S ratio in fodder sorghum and sorghum + cowpea was narrowed with S application. The critical limit of available S by heat soluble, sodium bicarbonates and calcium chloride extractable method worked out to be 8, 20 & 10 ppm for sorghum and 12, 30 & 13 ppm for sorghum + cowpea.

Integrated Nutrient Management

Chemical fertilizers and vermicompost

The field experiment was laid out to find out the combined effect of chemical fertilizers and vermicompost. The treatments included were four levels each of chemical fertilizers viz; control, 33% (30:20:10), 67% (60:30:20) and 100% (90:40:30) of recommended levels of N:P:K and vermicompost i.e. 0, 2.5, 5.0 and 7.5 t ha^{-1}. These treatments were tested on HC-136 variety of sorghum under randomized block design with three replications.

Kharif data revealed that sorghum green fodder and dry matter yields increased with each increase in fertilizer level. The maximum yield (GFY 64.4 and DFY 12.8 t ha^{-1}) was obtained under 100% of recommended fertilizer schedule (90:40:30 of N:P:K). Green fodder yield of sorghum under 100% of recommended fertilizer schedule was 100.0, 47.4 and 12.0 per cent higher over control, 33 and 67% of NPK respectively. Similar trend was also obtained for increasing levels of vermicompost. The green fodder and dry matter yields were 41.0, 45.5, 53.0 and 56.4 t ha^{-1} and 8.4, 9.3, 10.9 and 11.6 t ha^{-1} when vermicompost applied at the rate of 0, 2.5, 5.0 & 7.5 t ha^{-1} respectively.

Chemical fertilizers + biofertilizers

A field experiment was laid out to find out the effect of integrated use of chemical fertilizer and biofertilizers on the productivity of sorghum-berseem cropping sequence. The bio fertilizers used were *Azotobacter chroococcum* (N-fixer) in sorghum and PSB (*Pseudomonas striata*) in berseem. Treatments consisted of 6 nutrients level (nitrogen in sorghum and phosphorus in berseem i.e. 0, 25, 50, 75, 100 and 125% of recommended doses) and two

bio-fertilizer inoculation i.e. inoculated (*Azotobacter* in sorghum and PSB in berseem) and uninoculated. The trial was conducted in randomized block design with three replications. The variety PC-6 of sorghum and wardan of berseem was grown.

Kharif season data revealed that sorghum productivity was significantly influenced by application of nitrogenous fertilizer and *Azotobacter* inoculation. Green fodder and dry matter yields increased upto 112.5 kg N ha^{-1} (125%) but the yields obtained at recommended and 125% of recommended nitrogen level were non significant and these yields were significantly higher over rest of the levels. The green fodder yield under 125% of recommended nitrogen level was 40.3 t ha^{-1} and this was 135.6, 89.2, 56.8, 27.9 and 1.3 per cent higher over 0, 25, 50, 75 and 100% of recommended nitrogen dose. Azotobacter inoculation to sorghum increased green fodder yield and dry matter accumulation in comparison to uninoculated. The yields obtained were 28.0 and 30.6 t ha^{-1} under uninoculated and inoculated treatments respectively.

Irrigation Water Management

Perennial lucerne

The treatments comprising of three irrigation schedules (IW/CPE ratio of 0.5, 0.75 and 1.0 with 60 mm water at each irrigation), three cutting intervals (25, 35 and 45 days) and three potassium levels (0, 60 and 120 kg K_2O ha^{-1}) were evaluated in 3^3 partial confounding design with two replications.

During 4th year of study the green fodder yield of lucerne obtained from November to June, with irrigation at 0.75 IW/CPE ratio was significantly higher (646.6 q ha^{-1}) over irrigations at 0.5 and 1.0 IW/CPE ratio. The harvesting of crop at 35 and 45 days interval remained at par (649.8 q ha^{-1} and 644.4 q ha^{-1}, respectively) but this was significantly superior to that harvested at 25 days interval (543.8 q ha^{-1}). Potassium levels i.e. 60 and 120 kg ha^{-1} did not differ significantly from each other in forage production (630.3 and 627.3 q ha^{-1}) but produced significantly higher green forage over control (580.4 q ha^{-1}). However, during July to October, the green forage yield from 0.75 and 1.0 IW/CPE ratio treatments (184.3 and 193.2 q ha^{-1}) was at par but it was significantly higher over irrigation applied at 0.5 IW/CPE ratio (161.1 q ha^{-1}). As regards cutting interval during July to October, it was noted that 35 days cutting interval proved significantly better (205.8 q ha^{-1}) than 25 days (145.6 q ha^{-1}) and 45 days (187.3 q ha^{-1}).

The total forage yield per annum was significantly higher (830.2 q ha^{-1}) with irrigation applied at 0.75 IW/CPE ratio over 0.5 and 1.0 IW/CPE ratio. In this case 35 and 45 days cutting intervals (855.3 and 829.8 q ha^{-1}) were at par and both gave significantly higher forage yield over 25 days interval (693.6 q ha^{-1}). 60 and 120 kg K_2O ha^{-1} which were at par (818.6 and 811.6 q ha^{-1}), produced significantly higher forage yield over control (748.5 q ha^{-1}).

Thus perennial lucerne should be raised by irrigating the crop at 0.75 IW/CPE ratio adopting cutting interval of 35 days and fertilized with 60 kg K_2O ha^{-1} for higher ton-

nage and longer persistency.

The profile soil moisture depletion pattern (0-60 cm) for perennial lucerne during *rabi* season reveals that for the different cutting intervals irrespective of irrigation levels the moisture depletion increased as days of cutting interval decreased and maximum depletion was found at 25 days cutting interval (Fig.10). However, among different irrigation levels for all the cutting interval treatments profile soil moisture depletion increased from irrigation levels at IW/CPE ratio 0.5 to 0.75 and from 0.75 to 1.0.

Sorghum-berseem and forage bushes

The seedlings of forage bushes (*Sesbania sesban* & *Leucaena leucocephala*) were planted prior to the sowing of other experimental crops. After establishment of forage bushes five cropping systems {berseem-sorghum (C_1), sole sesbania at 0.5 m apart (C_2), sole subabool at 0.5 m apart (C_3), berseem-sorghum with sesbania alleys at 3 m apart (C_4) and berseem-sorghum with subabool alleys at 3 m apart (C_5)} were allocated to main plots whereas the three moisture regimes {IW/CPE ratio of 0.5 (I_1), 0.75 (I_2) and 1.0 (I_3)} to sub plots in a split plot design with three replications. Berseem was sown on November 1, 1996 and sorghum on May 14, 1997. Five cuttings from berseem, three from sorghum and three each from sesbania and subabool were taken.

The treatment variables significantly affected total green forage yields (obtained during November, 1996 to October, 1997). The green forage yields obtained under berseem-sorghum sequence (172.9 t ha^{-1}), berseem-sorghum with subabool alleys (163.5 t ha^{-1}) and berseem-sorghum with sesbania alleys (153.4 t ha^{-1}) were at par but these systems were significantly superior to sole sesbania (70.0 t ha^{-1}) and sole subabool (48.5 t ha^{-1}) in forage production.

The effect of irrigation levels on green forage yield was not well marked.

Cumulative profile soil moisture depletion for 0 to 60 cm depth showed that water depletion is highest under I_3 over I_2 & I_1 treatments (Fig.11). Whereas, among crop treatment the total soil moisture depletion was higher under C_4 as compared to the other cropping sequence and was found highest (45.2 cm) under I_3C_4 treatment.

Weed Management and Herbicides use

Bush control

During second year of the experimentation three herbicides with two different concentration (Glyphosphate 20 and 30, imazapyr 25 and 40, 2, 4-D + paraquat mixture 20 + 10 and 30 + 15% solution) were applied on cut stump of major bush species like *Acacia catechu, Mimosa rubiculis, Lantana camara, Butea monosperma, Zizyphus numaliria* and others.

The results revealed that application of concentrated herbicide solution on cut stump was found most effective and no sprouting was noticed. However, in case of control, resprouting from cut stump was observed.

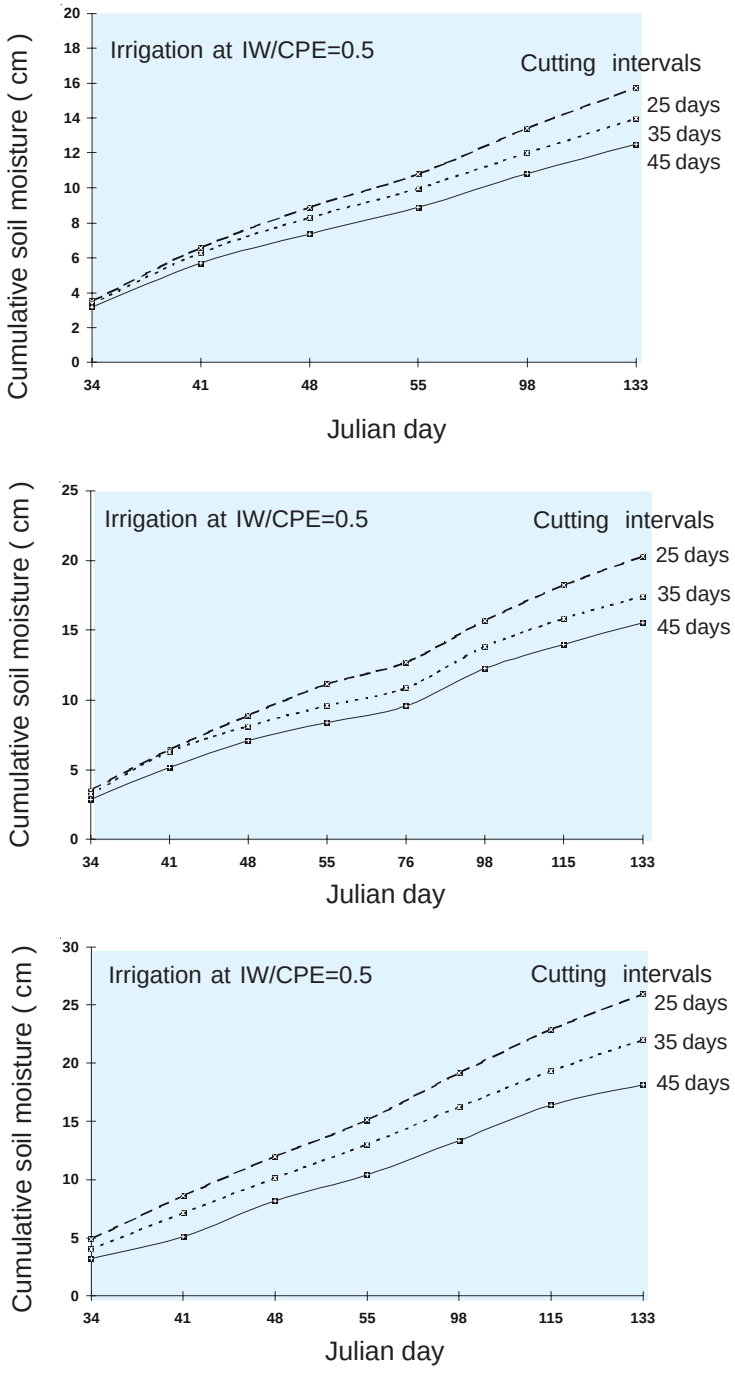


Fig. 10 : Profile soil moisture depletion pattern of perennial lucerne at different irrigation levels and cutting intervals

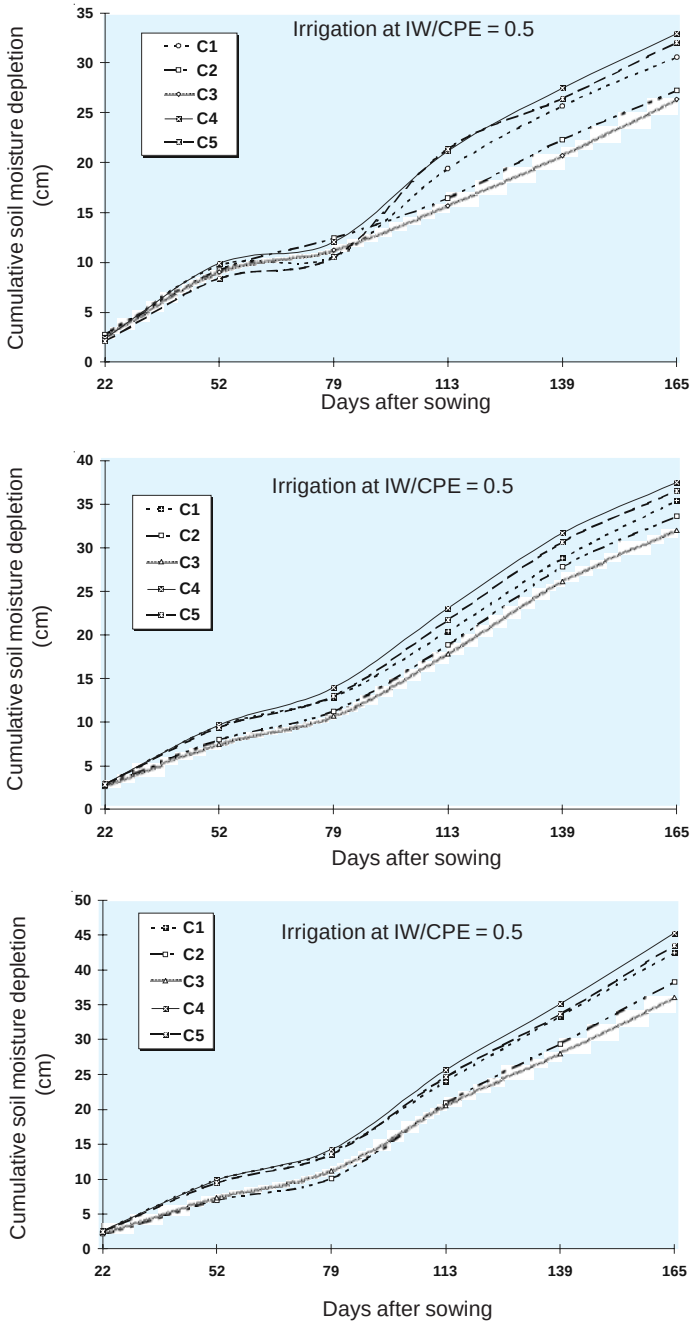


Fig. 11 : Profile soil moisture depletion pattern (0-60 cm) of alley cropping system at different irrigation levels

Interaction studies between herbicides and soil enzymes

Three major types of soil from the Central Research Farm of the Institute, e.g. *Rakar* (Entisol), *Parwa* (Alfisol) and *Kabar* (Inceptisol) were incubated separately with recommended dose of Alachlor (2 kg a.i. ha^{-1}) and Atrazine (0.75 kg a.i. ha^{-1}) under air-dry conditions at 37°C. The results are graphically presented in Fig. 12.

During incubation period data on microbial counts (bacteria, fungi and actinomycetes) show decreased trend from 6 to 15 days on application of Alachlor in Kabar soil. However, on day 30th it was substantially increased indicating, that there is a positive correlation between microbial population and dehydrogenase activity with application of Alachlor, but overall microbial and dehydrogenase activities were reduced. Similarly, application of Atrazine in *Kabar* soil and Alachlor in *Rakar* soil showed decreased microbial population on 15th day especially in respect of fungi and bacteria and again recorded an increased bacteria, fungi and actinomycetes population on 30th day, supporting the observations made with dehydrogenase activity due to the application of these herbicides.

FORAGE PRODUCTION SYSTEMS UNDER RAINFED CONDITIONS

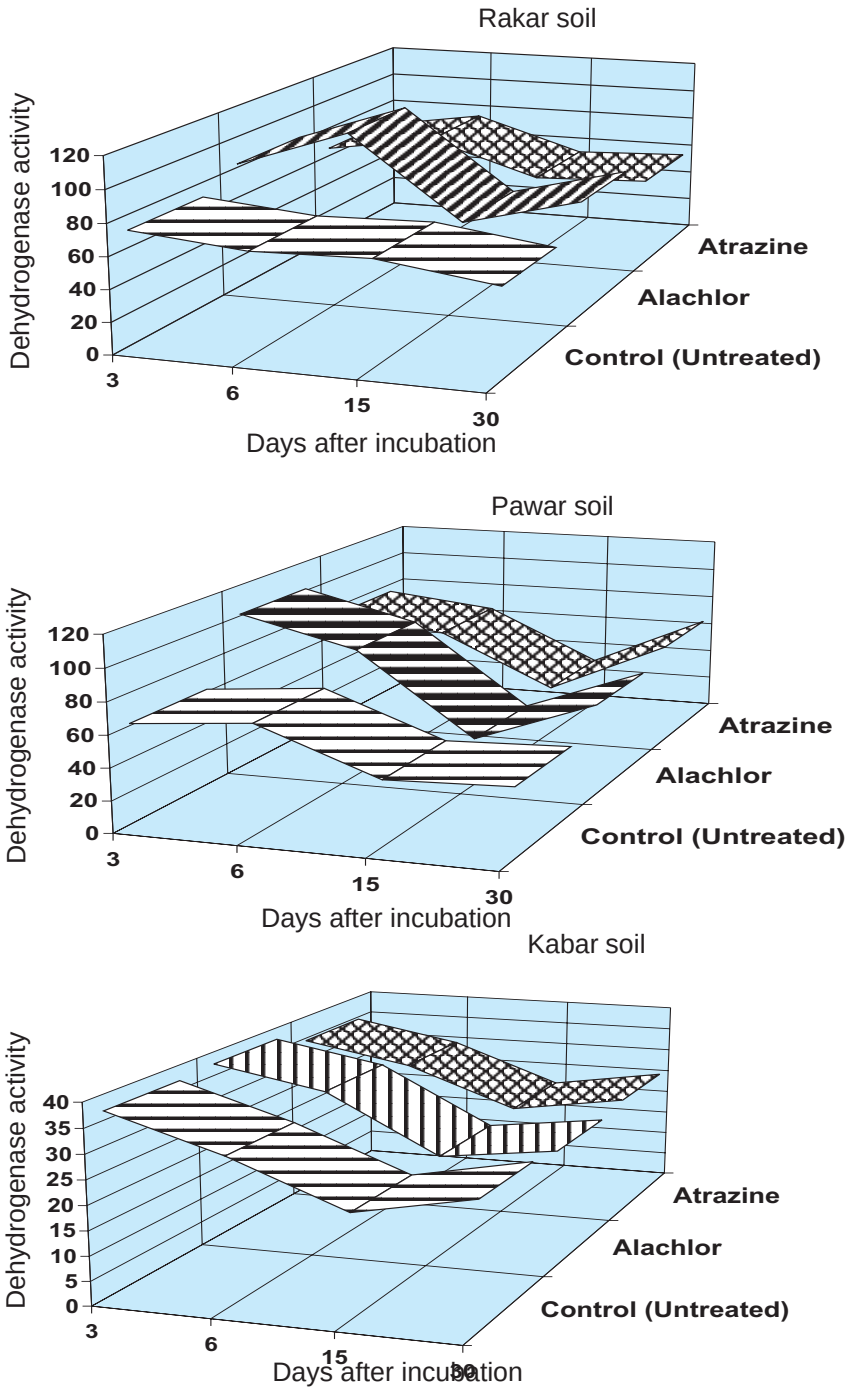
Cultural Management and Fertilizer Use

Soil moisture retention and fertilizer use

Treatment combinations involving five fodder based cropping systems *viz.*, cowpea-fallow, Dolichos-fallow, Castor alone, cowpea + castor and Dolichos + castor, two soil moisture relative measures i.e. flat and ridge of furrow sowing and two nutrient supply regimes *viz.*, 100% of inorganic fertilizer and 50% of each through inorganic and organic source were evaluated in split plot design with three replications. During first year significantly higher green fodder (152.5 q ha^{-1}) and dry matter (33.09 q ha^{-1}) yields were obtained with pure crop of *Dolichos* as compared to cowpea + castor cropping system, followed by cowpea (pure), Dolichos + castor and cowpea + castor systems. Among the soil moisture retentive measures, ridge and furrow sowing gave maximum green fodder (141.98 q ha^{-1}) and dry matter(29.67 q ha^{-1}) yields than flat sowing. Application of 50% each of inorganic and organic source produced significantly higher green fodder (137.29 q ha^{-1}) and dry matter (28.69 q ha^{-1}) over 100% inorganic sources.

Moisture conservation practices for forage and food crops

An experiment with three cropping systems viz. sorghum (selection J-6) - gram (radhey), cowpea (EC - 4216) - barley (ratna) and sorghum + cowpea - barley + gram; moisture conservation techniques i.e. three ploughing by desi plough each followed by planking, two ploughing by desi plough followed by bakkhar, use of jalshakti @ 5 kg ha^{-1} and use of weeder cum mulcher at 20-25 days after sowing (DAS) was conducted to find out the possibility of growing double cropping in the same field under *in situ* moisture conservation.



Activity expressed in microgram TPF formed/g soil/24 hrs

Fig. 12 : Soil dehydrogenase activity

During *kharif,* sorghum (sole) gave maximum green forage (51.25 t ha^{-1}) and dry matter (12.81 t ha^{-1}) yields followed by sorghum + cowpea (40.6 + 12.0 t ha^{-1}), dry matter (10.15 + 2.42 t ha^{-1}) and cowpea sole (green forage 35.55 t ha^{-1}) and dry matter (7.16 t ha^{-1}) yield. Among the moisture conservation techniques, jalshakti @ 5 kg ha^{-1} produced maximum green forage (45.0 t ha^{-1}) and dry matter yields (11.25 t ha^{-1}) followed by three ploughing by desi plough and each followed by planking (green forage 43.0 t ha^{-1}, dry matter 10.85 t ha^{-1}), weeder cum mulcher (green forage 42.35 and dry matter 10.59 t ha^{-1}) and two ploughing by desi plough + bakkhar green forage (39.25 t ha^{-1}) and dry matter (9.81 t ha^{-1}) yield.

N & P management in *Pennisetum trispecific hybrid* + *Stylosanthes hamata*

The treatment combinations involving three cropping systems *viz., Pennisetum trispecific* hybrid alone, *S. hamata* alone and their mixture (1:1), four levels of nitrogen *viz*., 0, 30, 60 & 90 kg ha^{-1} and three phosphorus levels *viz*., 0, 30 and 60 kg P_2O_5 ha^{-1} were evaluated in split plot design with three replications. The soil of the experimental plot was clayey (45.47 clay, 22.57 sand and 29.17 silt) with a pH 7.1. Rooted slips of the grass were planted at uniform spacing of 50 cm between rows and plants in the last week of August, 1997 where as *S. hamata* was sown at 50 cm row distance. The plant population and plant height were recorded at the time of cutting. Only one cut could be taken from the grass component in 2nd week of November. The stand of stylo was inadequate, therefore, the yield of legume component was not recorded.

The higher green forage (137.7 q ha^{-1}) and dry matter yields (45.90 q ha^{-1}) were obtained with the application of 90 kg N + 60 kg P_2O_5 ha^{-1}. This was followed by 90 kg N + 30 kg P_2O_5 ha^{-1} production. Minimum green fodder (74.3 q ha^{-1} and dry matter (24.76 q ha^{-1}) was recorded in control plot.

Biological Nitrogen Fixation

Bradyrhizobium strain selection

The results of the previous studies, showed greater competitiveness and suitability of native strains in *S.hamata*. In view of this, five more local isolates (JSR-10, JSR-11, JSR-12, JSR-13 and JSR-14) of Bradyrhizobium were evaluated on *S.hamata* for their relative effectiveness against three highly efficient strains (CB-82, JSR-3 and JSR-4) along with two control treatments (uninoculated control and uninoculated control + 20 kg N ha^{-1}) under pot condition in red soil (sandy loam). Data revealed superior performance of local isolates (JSR-11 & JSR-12) in respect of dry forage yield (+ 48.6%), nodulation (53-70 plant), nitrogen uptake (192.6 mg N/pot) and in relative efficacy (121-123%) as compared to exotic strain (Australia-CB-82). Maximum improvement in forage yield (green forage - 40.9 g/pot; DM-11 g/pot) and crude protein content (12.5%) was recorded with JSR-12, followed by JSR-3 (green forage- 40.6 g/pot; DM-10.9 g/pot). Inoculation by different Bradyrhizobium strains resulted in 15.9 to 49.4% higher dry forage yield over uninoculated control.

Host genotype-Bradyrhizobium studies

With a view to evolve strain(s) preferring more than one host spp., a pot study was initiated using red soil (sandy loam) with two stylo species (*S.hamata* and *S.humulis*) six strains (native-JSR-3, JSR-4, JSB-4; exotic-TAL-309, CB-82 and ISI-2) and two control treatments (uninoculated control, uninoculated control + 20 kg N ha^{-1}). Among the strains, JSR-3 was found to be most compatible in giving maximum green and dry forage yield (+45-48%), root length (29.9-31.7 cm/pl) and strain occupancy in nodules (100%) in both the species and it was followed by JSR-4. The results indicated 43.5-48.4% higher benefits from native strains i.e. JSR-3 and JSR-4 than that of the exotic ones (+21-40%).

Nutrient Dynamics in Grass - Legume Pastures

Nitrogen and potassium management

In 1997 *kharif* season, a field experiment was conducted with *Cenchrus ciliaris* - *Stylosanthes hamata* mixed pastures to investigate above and below ground nutrient transformations and flows for increasing forage yields, long-term persistence and sustainable soil quality. The experimental soil was *rakar* having low organic-C (30 g $kg^{-1}$of soil) and total-N (0.32 g/kg).

A field experiment consisting three levels of nitrogen (0, 40 kg N ha^{-1} through urea and 20 kg N ha^{-1} each through urea and slurry) and 4 levels of potassium (0, 40, 80 & 120 kg K ha^{-1}) was conducted in RBD design with three replicates. At the time of sowing, stylo seed was treated with an efficient strain of Bradyrhizobium (JSR-4 strept).

Results from a single cut revealed that the highest green forage production (111 q ha^{-1}) was obtained with the treatment of N_{40} + K_{120} followed by N_{40} + K_{80}.

Analysis of the soil samples (0-10 cm), showed that available nutrient, particularly NO_3-N, did not differ due to different treatments. However, a trend of higher NH_4^+-N content (8.5 - 13.4 mg $kg^{-1}$of soil) was observed in soils where application of K was at 80-120 kg ha^{-1}. Data on nodulation behavior at varying levels of inputs indicated a tendency of higher nodulation (105/plant) when application of K was at 80-120 kg ha^{-1}.

FORAGE PRODUCTION UNDER PROBLEM SOILS

Performance of forage crops grown on saline-sodic soils under different sources of soil amendments

Grasses

The experiment comprising six forage grasses i.e. *Chloris gayana, Leptochloa fusca, Brachiaria mutica, Setaria sphacelata, Sorghum sudanensis* and *Panicum maximum* and three sources of amendment viz UTM (User Tod Masala @ 5 t ha^{-1}), gypsum 5 t ha^{-1} and urea 90 kg ha^{-1} was conducted on saline sodic soils. The grasses were planted in July 1997. Soil and plant samples representing uncultivated/barren site at UPLDC farm Shiver (Mohan Road, Lucknow) were collected for physico-chemical properties and biomass regeneration studies. The initial values of physico-

chemical properties of the soil were : pH 10.7, EC 2.9, OC 0.10% and available P_2O_5 4.5 kg ha^{-1}. The gypsum requirement of this soil was worked out to be 9.2 t ha^{-1}.

Maximum survival of *Leptochloa fusca* (97%) was recorded which was followed by *Brachiaria mutica* (96%), *Setaria sphacelata* (84%) *Chloris gayana* (80%), *Sorghum sudanesis* (54%) and *Panicum maximum* (51%). Similar trend was observed in case of yield and yield attributes.

Forage Production under Seasonal Waterlogged Conditions

Grass species and cutting management

Under seasonal waterlogging conditions two grass species *viz*., Almen grass (*Echinocloa polystachya*) and para grass (*Brachiaria mutica*) and three cutting managements *viz*., 2, 3 and 4 cuttings were evaluated in randomized block design with four replications. Both the grasses were transplanted on 28.7.97 at 50 x 30 cm apart. One cutting was taken in December. Significantly higher green fodder (100.98 q ha^{-1}) and dry matter (32.03 q ha^{-1}) yields were obtained in almen grass as compared to para grass (72.5 q ha^{-1} green fodder and 21.69 q ha^{-1} dry matter yield).

AGROCLIMATOLOGICAL APPROACHES

Forage crop planning for Bundelkhand region

Mar soils

Weekly water balance model was computed for the period 1970-97 for '*mar*' soil (actual water holding capacity 'AWHC'= 207mm) of Bundelkhand region to assess the suitability of crops and cropping systems in a given soil-climate complex. Different water balance parameters e.g. moisture adequacy index, available soil moisture were worked out utilising weekly rainfall data and normal potential evapotranspiration. The start, end and duration of the crop growing season was determined for three decades i.e. 1970-79, 80-89 & 90-97 and decadal variation of moisture adequacy index (MAI) (Fig. 13) has also been computed for '*mar*' soils.

The results indicate that the growing season started (MAI > 0.5) in the 25th and 26th standard meteorological week during 1970-79 and 80-89 respectively. Whereas, it was 28th week during 90-97. The mean length of crop growing season (1970-97) for '*mar*' soils (Fig. 14) was about 24 weeks. Further, the length of the crop growing season was of 24, 24 and 23 weeks duration during 1970-79, 80-89 and 90-97 respectively which shows that the crop growing season has decreased by one week in recent decade compared to previous decades.

Evapotranspiration Studies

Berseem

Berseem cv. Wardan was sown in and around lysimeter during rabi 1996-97. A basal dose of 20 kg N ha^{-1} and 80 kg $P_2O_5 ha^{-1}$ was applied. Observations on evapotranspiration (ET) were recorded on day to day basis. During 170 days of crop growth period 758.0 mm cumulative ET was recorded which gave mean value as

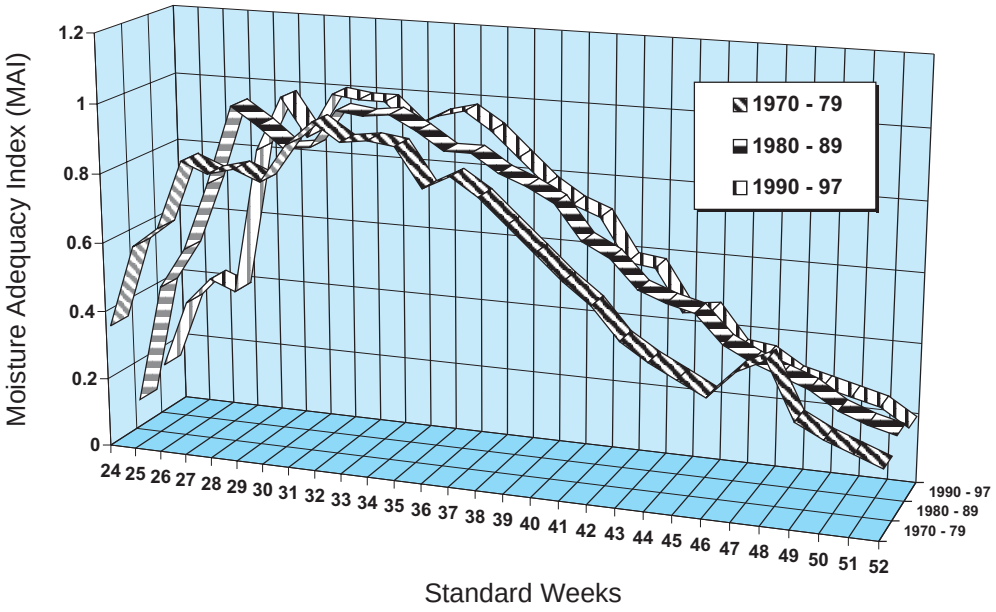


Fig. 13 : Decadal variation of MAI for mar soils during crop growing season

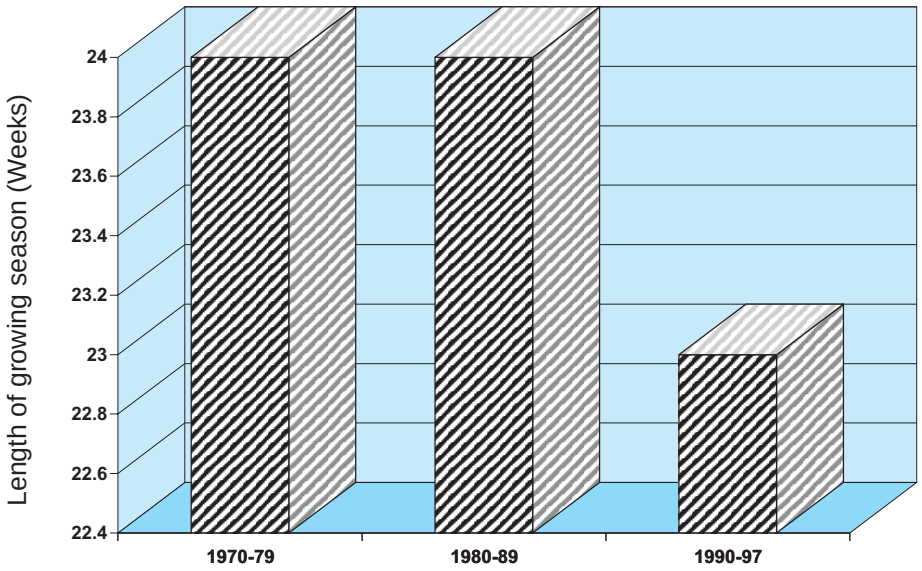


Fig. 14 : Decadal variation of length of growing season for crop planning in mar soils (AWHC = 207 mm)

4.8 mm/day. Cumulative green forage yield of 109.47 t ha^{-1} was obtained in five cuttings at an interval of 53, 30, 30, 29 and 28 days. On the basis of different cuttings, the mean water use efficiency was 24.1 kg dm/ha/mm for lysimeter. Higher green forage yield was obtained at fourth cutting (30.18 t ha^{-1}) at 29 days of cutting interval followed by third cutting (29.59 t ha^{-1}) at 30 days cutting interval (Table 24).

In *kharif* 1997, maize + cowpea in paired row spacing (25 cm) was sown in and around lysimeters. A basal dose of 60 kg N ha^{-1} and $P_2O_5 ha^{-1}$ was applied. During 68 days of crop growth period ET for 56 days was recorded 6.7 mm/day. The total ET for combined crop growth period was calculated to be 455.6 mm. The water use efficiency for mixed cropping was 15.4 kg dm/ha mm for lysimeter. The green forage yield of maize and cowpea was 16.57 and 18.93 t ha^{-1} on lysimeter and 11.44 and 9.83 t ha^{-1} at field respectively (Table 25).

Measurement of nutrients leaching, using lysimeters in the field, has been continued for the 4th year (i.e. 1997). This year, during June-December, total rainfall was higher (949 mm) than the previous years (1994-96), but unlike earlier years the losses of N remained much lower (37.0 kg ha^{-1}) because of better distribution of total rainfall and the absence of large storms (Fig.15) in the *kharif* season. This year an unusual phenomenon was the excess winter rains during the first half of December. Interestingly, the impact of such rains, however, was not high on NO_3^--N leaching (12.1 kg ha^{-1}) from the soil profile, presumably due to low average temperatures (15°C) resulting into slow net N mineralization rates and less availability of NO_3^--N pool for leaching.

Table 24 : Forage yield, water use efficiency and evapotranspiration of berseem at different cuttings

Cutting	G.M. Yield (t ha^{-1})		D.M. Yield (t ha^{-1})		Periodical ET (mm)	ET (mm/day	Water use efficiency kg dm/ha/mm (on Lys.)
	Lys.	Field	Lys.	Field			
I	18.34	14.00	2.22	1.50	139.2	2.6	15.9
II	13.61	15.11	1.69	1.84	72.3	2.4	23.4
III	29.59	26.33	4.29	3.61	126.6	4.2	33.9
IV	30.18	22.56	5.55	4.26	199.4	6.9	27.8
V	17.75	8.18	4.29	2.03	220.5	7.9	19.5
Total	109.47	86.18	18.04	13.24	758.0	-	-
Mean	-	-	-	-	-	4.8	24.1

Table 25 : Forage yield, water use efficiency and ET of maize + cowpea

Crop	G.M. Yield (t ha^{-1})		D.M. Yield (t ha^{-1})		Total ET crop in mm	Water use efficiency kg dm/ ha mm (on Lys.)
	Lys.	Field	Lys.	Field		
Maize	16.57	11.44	3.36	1.93	-	-
Cowpea	18.93	9.83	3.67	1.47	-	-
Total	35.50	21.27	7.03	3.40	455.6	15.4

Dynamic growth simulation model

Sorghum

During *kharif* season, growth and development of two promising varieties of sorghum i.e. PC-6 and HC-136 were assessed under different range of environmental conditions by three dates of sowing i.e. 5.7.97 (D_1), 28.7.97 (D_2) and 16.9.97 (D_3) in a medium black soil. Physiological and meteorological parameters were recorded at different days of interval.

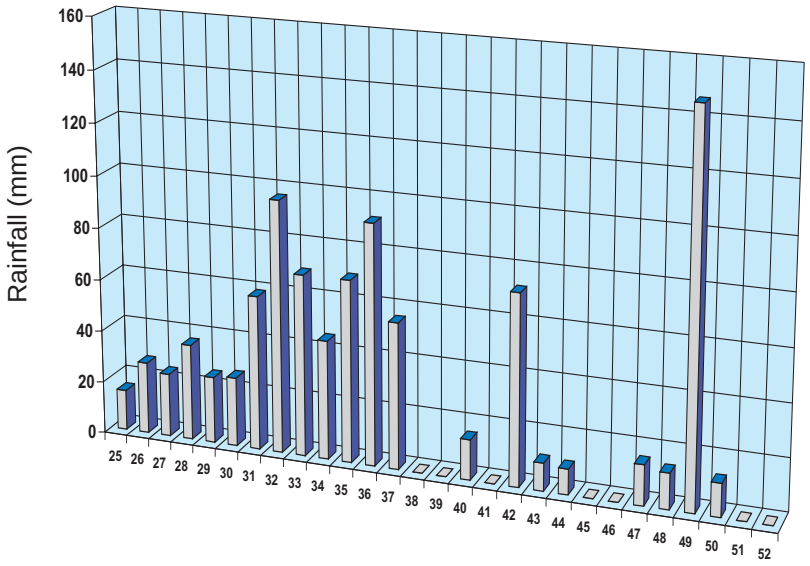


Fig. 15 : Rainfall distribution pattern during June to December 1997

The mean,maximum and minimum temperature was highest during D_1 and lowest during D_3, whereas mean bright hour's of sunshine was highest during D_3 and lowest during D_1 (Table 26).

The duration of emergence to 50% flowering varied from 66-94 and 74-105 days in PC-6 and HC-136, respectively. Plant attributes such as plant height, number of leaves, leaf area index (LAI), specific leaf weight and dry matter yield are shown in table 27 at different days of interval for both the varieties. It was noticed that net above ground green biomass in HC-136 is higher than PC-6 during D_1. But during D_3 PC-6 performed better than HC-136 indicating that HC-136 is much influenced by night temperature. Similar trend was observed in dry matter yield too.

At each harvest,green and dry biomass accumulation were analysed as the product of growing degree days (GDD) and bright hour's of sunshine for each date of sowing from emergence to 50% flowering. It can be seen that GDD and thermal use efficiency (TUE) varied under different aerial environmental conditions for both the varieties, which indicates that growth and development is not only the function of temperature alone but also influenced by some other parameter, such as radiation or sunshine.

Regression equation between dry/green biomass (dependent variable) and GDD and sunshine hour's revealed that in most of the cases, yield variation was influenced by GDD and BSS more than 90%. The fitted slope of GDD and BSS hour's for both the varieties was lower during D_2. However, the intercept of the fitted linear relationship was significant and negative in most of the cases for both the varieties (Table 28).

Impact of NWDB Project

The impact of NWDB project from 1991-92 to 1994-95 on land use and cropping pattern at Ambabai village, Jhansi (U.P.) was assessed through field level surveys. The noted changes observed in case of land use were about 11 ha of wasteland is added under settlement i.e., private premises and Govt. undertaking (Bharat Petroleum) and 21 ha of fallow land has been converted into irrigated regular sown area. The significant change in cropping pattern due to adoption of improved technologies under NWDB programme is manifested through increased productivity levels of all crops and increase in area under cultivation in both *rabi* (10.7%) and *kharif* (23.7%) seasons in 1997-98 over the base year 1991-92. With the expansion of irrigation facility, crops like barley, gram and lentil has been replaced with wheat, pea and berseem which are more remunerative. The impact is also found on grasses where area, production and productivity have been gone up by 79.9%, 93.8% and 7.3% respectively.

Table 26 : Agro-climatic elements and net above ground mass of two sorghum varieties under three different dates of sowing

	Variety	Sowing dates		
		5.7.97 (D_1)	28.7.97 (D_2)	16.9.97 (D_3)
Maximum Temperature (°C)	PC-6	32.6	31.7	30.9
	HC-136	32.3	31.1	30.4
Minimum Temperature (°C)	PC-6	24.8	21.2	16.3
	HC-136	23.0	20.7	16.1
Sunshine hour's (hr)	PC-6	5.2	6.1	7.9
	HC-136	5.4	6.2	7.6
Cumulative Sunshine (hr)	PC-6	459.8	578.5	524.7
	HC-136	582.5	627.5	543.8
Duration in days (Emergence to 50% Flowering)	PC-6	88.0	94.0	66.0
	HC-136	105.0	101.0	74.0
Net above ground mass (q ha^{-1})	PC-6	225.0	138.0	288.0
	HC-136	275.0	139.0	168.0
Cumulative degree days (Emerg. to 50% Flowering °C days)	PC-6	1820.0	1734.0	1028.0
	HC-136	2063.0	1809.0	1091.0
Thermal use efficiency (q ha^{-1} °C days)	PC-6	0.12	0.08	0.28
	HC-136	0.14	0.08	0.15

Table 27 : Morpho-physiological characteristics of sorghum varieties with respect to two different dates of sowing at different days of interval

Plant character-stics	Date of sowing	Variety	Days after sowing					
			20	40	60	80	90	110
Plant height (cm)	D1	PC-6	11.2	70.0	117.0	180.0	215.0	216.0
		HC-136	10.2	89.0	98.0	157.0	185.0	227.0
	D2	PC-6	12.9	25.0	85.0	-	143.0	170.0
		HC-136	16.5	19.0	73.0	-	130.0	155.0
Number of leaves	D1	PC-6	3.1	4.3	5.1	7.1	6.7	5.9
		HC-136	3.1	4.9	5.6	6.9	7.2	6.2
	D2	PC-6	3.1	3.2	5.0	-	6.5	5.4
		HC-136	2.7	3.1	5.3	-	6.8	6.3
Leaf Area Index (LAI)	D1	PC-6	0.22	2.2	4.4	5.4	4.8	3.5
		HC-136	0.20	2.3	3.7	6.8	5.7	4.2
	D2	PC-6	0.5	1.6	2.6	4.5	5.5	5.1
		HC-136	0.3	1.1	2.1	3.7	6.3	6.5
Specific leaf weight (mg cm^{-2})	D1	PC-6	2.0	3.7	4.4	4.8	4.6	3.8
		HC-136	2.1	3.9	3.9	4.4	5.0	4.4
	D2	PC-6	1.9	2.2	5.3	5.8	4.6	3.2
		HC-136	1.8	2.6	5.6	6.2	4.4	3.0
Dry matter yield (g m^{-2})	D1	PC-6	6.2	159.1	383.4	879.8	1056.0	1214.0
		HC-136	5.4	202.4	299.0	997.8	1146.0	1278.0
	D2	PC-6	13.5	55.3	283.2	397.8	654.0	1001.3
		HC-136	7.2	33.9	206.5	478.3	733.0	1142.3

Table 28 : Linear regression equation between dry/green forage yield with growing degree days (GDD) and bright hour's of sunshine (BSS) along with coefficient of determination during first and second date of sowing

Date of sowing	Variety	Equation	R^2
D1	PC-6	YG = -683.9 + 2.4 GDD	0.87
		YD = -356.8 + 0.73 GDD	0.94
	HC-136	YG = -458.4 + 1.97 GDD	0.86
		YD = -314.6 + 0.7 GDD	0.94
	PC-6	YG = -296.6 + 7.1 BSS	0.73
		YD = -111.7 + 2.33 BSS	0.93
	HC-136	YG = 349.9 + 5.9 BSS	0.72
		YD = -88.9 + 2.2 BSS	0.92
D2	PC-6	YG = -926.0 + 1.8 GDD	0.97
		YD = -385.7 + 0.59 GDD	0.77
	HC-136	YG = -1253.3 + 2.16 GDD	0.96
		YD = -324.2 + 0.49 GDD	0.88
	PC-6	YG = -345.4 + 4.37 BSS	0.97
		YD = -227.1 + 1.5 BSS	0.86
	HC-136	YG = -561.8 + 5.3 BSS	0.97
		YD = -185.7 + 1.2 BSS	0.97
D1	PC-6	YD = -294.0 + 0.7 BSS + 0.5 GDD	0.92
	HC-136	YD = -253.2 + 0.7 BSS + 0.5 GDD	0.94
D2	PC-6	YD = -18.1 + 3.2 BSS - 0.7 GDD	0.91
	HC-136	YD = -42.1 + 2.3 BSS - 0.4 GDD	0.99

YG = Green Yield
YD = Dry Yield

3.3 GRASSLAND AND SILVOPASTORAL MANAGEMENT

RESOURCE INVENTORY

Grazing Resource Inventory of Lower Sind Catchment

Based on Survey of India Toposheets number 54 F, G, H, J & K on 1/250,000 scale, the thematic map on major landform units *viz*., Hilly area, upland dissected plateau, monadrocks, pediments, undulating terrain, rocky surface, gentle slopping plain, ravines & gully and river valley were prepared for the superimposition of classified satellite image. The maps related to forest cover and area affected with ravines were generated on the basis of IRS-IA/1B FCC ROW 49 & 50, RATH 27 & 28, Band 2, 3 & 4, LISS-I, dated March 1995. The study reveals that the area under ravines is closely associated with the tributaries flowing through undulating and gentle slopping plain. The intensity and severity of ravines was found to be more near the confluence zones and both sides of the channels in middle and lower courses. The lateral and head ward erosion was minimum along the sind river.

During this year, 6 sites were selected from different landform units for the study of slope profile (Fig.17) and its geobotanical impact on vegetation cover (Fig.18) with the help of determining the index of dominances (c) and it has been observed that out of 9 slope profiles, 6 vegetative slope profiles are having comparatively lower dominanace and higher species diversity. The channel bed (F) and shoulder segment seepage slope (D) are comparately higher in dominance in comparison to other slope categories. The F and D slopes of vegetation stands are having index of similarity(S) as 0.4 and are represented by the common species of *Heteropogon, Dichanthium*; *Sehima* within grasses and *Indigofera, Carissa* amongst legumes and shrubs.

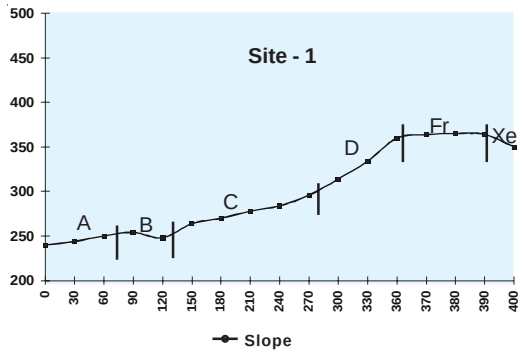
NON-CONVENTIONAL AND UNDER-UTILIZED SPECIES

Forage groundnut

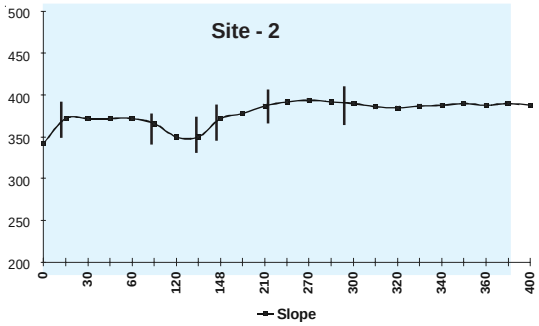
In monsoon period, maximum biomass (dry matter) was recorded in *Arachis glabrata* (766 gm/m^2) followed by *A. hagenbackii* (628.8 gm/m^2) and *Arachis* sp. (IFL 2273) (597.1 gm/m^2). Maximum regrowth in the postmonsoon season was noted in *A.glabrata*. Weed infestation was lowest in *A. hagenbeckii* and maximum in *Arachis* sp. IFL.2273.

Forage shrubs

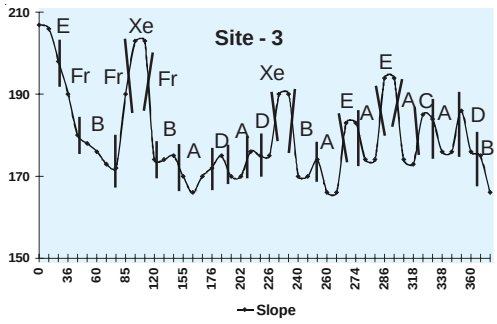
The observations on growth parameters of under utilized shrubs *viz*., *Ehretia aspera, Flacourtia indica, Grewia flavescens, Helicteres isora* and *Securinega virosa* were continued this year. *S. virosa* showed maximum shrub volume (5.4 m^3) followed by *Helicteres isora* (2.8 m^3), *Grewia flavescencs* (1.8 m^3) and *E. aspera* (0.6 m^3). Maximum plant height and number of secondary



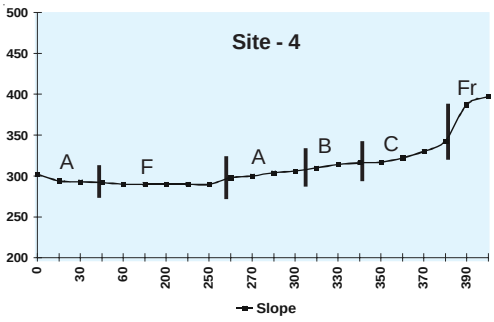
Latitude : 25 23' 55" Longitude : 78 30' 50"



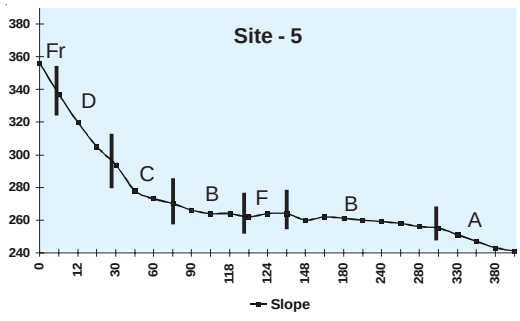
Latitude : 26 25' 15" Longitude : 78 21' 45"



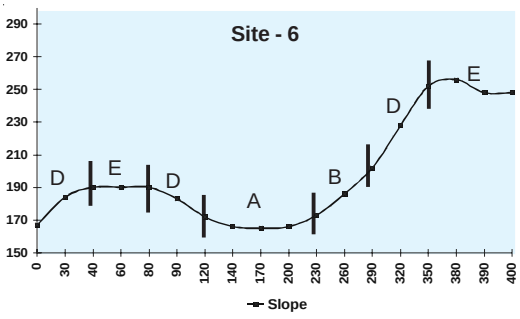
Latitude : 25 53' 41" Longitude : 78 51' 04"



Latitude : 25 21' 45" Longitude : 78 04' 15"



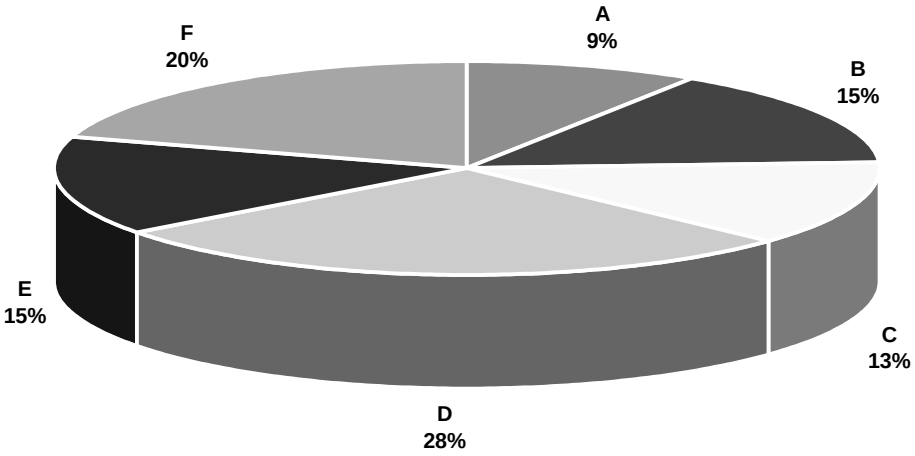
Latitude : 25 30' 49" Longitude : 78 22' 30"



Latitude : 25 30' 45" Longitude : 78 36' 45"

A : Toe slope B : Collusive foot slope C : Planner segment side slope Xe : Summit
D : Shoulder segment seapage slope E : Inter flue crust R : Road F : Channel bed
Fr : Free face

Fig. 17 : Study of slope profile



Dominance index

Fig. 18 : Slope categories and plant diversity

branches was recorded in *S. virosa* (43.2 ± 27.5) (Table 29). *G. flavescens* exhibited the diversity in respect to flowering and fruiting. *Ehretia aspera* showed slow growth in post monsoon season in comparison to other shrubs. *H. isora* and *S. virosa* showed diversity in shape and size of leaves.

Leucaena germplasm

Fourteen provenances of five *Leucaena* species *viz*., *L. collinsii* (5), *L. diversifolia* (3), *L. pulverulenta* (3), *L. salvadorensis* (2) and *L. stenocarpa* (1) alongwith *L. leucocephala* K8 were transplanted in randomised block design with three replication to assess the growth parameters.

Table 29 : Growth performance of two year old under-utilized shrubs

Shrub spp.	Plant height (cm)	Primary branches (No.)	Secondary branches (No.)	Average shrubs volume (Cubic meter)
Ehretia aspera	87.1±27.0	2.3± 1.4	8.4± 3.9	0.6
Flacourtia indica	189.7±32.5	5.2±2.3	34.5±16.5	4.9
Grewia flavescens	107.5±21.2	13.1±5.7	19.3±8.7	1.8
Helicteres isora	136.3±19.0	9.0±2.1	15.4±5.2	2.8
Securinega virosa	192.4±49.4	4.4±2.2	43.2±27.4	5.4

At species level, the best survival was obtained in *L. collinsii* (92.6%) followed by *L. salvadorensis* (88.9%). L. stenocarpa (66.7%). Maximum plant height was attained by *L. salvadorensis* (161.8 cm) followed by *L. collinsii* (143.7 cm) and *L. pulverulenta* (33.6 cm). Collar diameter was found better in *L. leucocephala* K8 (1.5 cm) followed *by L. collinsii* (1.4 cm) while it was lowest in *L. pulverulenta* (0.4 cm). The maximum number of primary branches were recorded in *L. collinsii* (11) followed by *L. leucocephala* K8 (10) while these were less in *L. pulverulenta* (3). The length of primary branches was higher in *L. salvadorensis* (72.2 cm) followed by *L. collinsii* (70.6 cm) while this was less in *L. pulverulenta* (10.5 cm). The length of secondary branch was recorded more in *L. collinsii* (20.8 cm) followed by *L. salvadornsis* (19.9 cm) while it was 7.0 cm in *L. pulverulenta*.

Flowering phenology and pure germinating seed yield in range grasses

Studies on initial head emergence (IHE), peak head density, tiller fertility, seed yielding components, seed setting and seed germination etc. were repeated during the year in 22 range grasses (Table 30). Unusual weather condition (intermittant rains and low temperature) during summer advanced reproductive phase in early flowering grasses *viz*., *Cenchrus* sp., *B. brizantha* and *P. antidotale* as IHE was recorded earlier in comparison to previous years. However, reproductive phase was delayed by 10-15 days due to extended rainfall in October onwards in species like *H. contortus, B. intermedia* and *C. fulvus.* Inflorescence exsertion and seed production was also prolonged upto mid November, unlike previous years. Advancement in IHE was also recorded in perennial *Pennisetum pedicellatum, P. polystachion* and *Chloris gayana*, which flowered under short day conditions. However, no variation was observed in IHE of *Andropogon gayanus*. In general prevailing climatic condition during inflorescence exsertion and anthesis adversely affected seed setting resulting in significantly lower per cent germination in spikelets in majority of species as compared to previous years. However, higher seed setting (35-40%) was recorded in *P. pedicellatum* and *P. polystachyon* during the year. *A. gayanus* was affected most due to unusual weather condition, where seed setting was reduced to 5-10% as compared to 30-35% during the year 95 and 96. No seed setting was recorded in *B. mutica* and *C.gayana*.

Tiller density, tiller fertility, inflorescence density and seed yielding components were also investigated in seven species. Potential seed yield was estimated by multiplying head density with mean spikelets/head. In *Brachiaria decumbens* tiller density was 682 tillers/m^2 with 55% tiller fertility having mean panicle length of 14.4 cm bearing 135 spikelets/head. Cent per cent tiller fertility was recorded in *H. contortus* with 463 tillers and 3100 inforescences/m^2. Mean seed yield nos./head was 8.45 with potential seed yield of 26195 nos./m^2. Seed test weight (1000 spikelets) was 3.568 g as compared to 5.682 in 1995. In case of *P. pedicellatum*, tiller density was 201/m^2

Table 30 : Time of initial head emergence (IHE), peak head density (PHD) and seed setting in 21 range grasses

Species	IHE	PHD	Seed set (%)
Apluda mutica	Oct. mid	Nov. mid	47
Andropogon gayanus	Nov. 2nd week	Dec. end	10
Bothriochloa intermedia	Oct. 2nd week	Nov. mid	54
Bothriochloa pertusa	Sept. 2nd week	Oct. mid	54
Brachiaria brizantha	July end	Aug. mid	32
Brachiaria decumbens	Aug. 3rd week	Sept 2nd week	21
Brachiaria mutica	Oct. mid	Nov. mid	Nil
Brachiaria ruziziensis	Nov. 1st wek	Dec. mid	31
Chloris gayana	Nov. mid	Dec. mid	Nil
Chrysopogon fulvus	Oct. 2nd week	Nov. 2nd week	48
Dichanthium annulatum	Sept. end	Oct. end	61
Heteropogon contortus	Sept. mid	Oct. mid	35
Melanis minutiflora	Nov. 3rd week	Dec. end	Nil
Panicum antidotale	July end	Aug. end	53
Sehima nervosum	Sept. 1st week	Sept. mid	15
Setaria sphacelata	Aug. 1st week	Oct. mid	37
Panicum maximum	Sept. 1st week	Nov. mid	53
Pennisetum pedicellatum	Oct. 3rd week	Dec. 1st week	40
Pennisetum polystachion	Nov.2nd week	Dec. mid	35
Themeda quadrivalvis	Sept. 2nd week	Oct end	27
Vetiveria zizanioides	Aug. 2nd week	Aug. end	34

with 82.5% tiller fertility. Inflorescence density was 259/m^2, with mean panicle (apical) length of 10.1 cm bearing 161 nos. spikeletes/head. Axillary panicles measured 4-6 cm with poor seed setting.

REVEGETATION OF DEGRADED LANDS

Revegetation of ravines

At the Research Farm of Central Institute for Research on Goat, Makhdoom six

months old saplings of three tree species *viz*., *Acacia nilotica* (desi babool), *Azadirachta indica* (neem) and *Ficus rumphii* (Pakar) were transplanted during July 1997 at 10x10 m distance in the established pasture of *Cenchrus* and *Pennisetum*. For plugging the gullies sand bags were stacked at the tail of gullies.

Establishment and growth data on woody vegetation revealed that *F. rumphii* showed highest survival (71.9 %) and diameter (0.71 cm) at 25 cm from ground level followed by *A. nilotica* (65.6 % and 0.28 cm respectively) while average number of branches was maximum (3.3) in *A. nilotica* followed by *F. rumphii* (2.7). *A. indica* expressed lowest survival (53.2 %) and growth characters (0.20 cm dia and 2.5 average number of branches). The soil moisture recorded at two depths (0-15 and 15-30 cm) of all the three habitats (flat, elevation and gullies) revealed that it was maximum at gullies followed at flat and was minimum at elevation.

Among the grasses *Cenchrus ciliaris* expressed better vigour than *Pennisetum pedicellatum* (Table 31).

Operational Research Project - Ambabai

Forage production of three silvipastures viz., *Dalbergia sissoo, Prosopis juliflora* and *Albizia amara* was evaluated against a natural grassland system. In comparison to natural grassland (6.4 t/ha), *Dalbergia* pasture produced more forage (54.8 %) followed *Albizia* pasture (5.3 per cent higher). Highest litter production was recorded from *Albizia* pasture (2.3 t/ha) followed by *Prosopis* (2.1 t/ha) and *Dalbergia* (1.5 t/ha) against natural grassland (0.4 t/ha). In these pastures the legume component was very poor.

In addition to the maintenance of above pastures about 2.0 ha pasture of *Cenchrus ciliaris* + *Stylosanthes hamata* was established with the participation of local village people.

GRASS-LEGUME PASTURE

Effect of planting pattern and harvest frequencies

A trial was laid out with four planting patterns of grasses and legumes and four harvest frequencies. In a mixed pasture four grasses *viz*., *Pennisetum* trispecific hybrid (*P. americanum x P. purpureum*) x *P. squamulatum, Pennisetum pedicellatum (perennial), Chrysopogon fulvus* and *Andropogon gayanus* and five legumes *viz*., *Stylosanthes hamata, S. scabra, Macroptilium atropurpureum, Clitoria ternatea* and *Atylosia scarabaeoides* were sown together as per seed rates recommended for each species.

Both, planting pattern and harvest frequencies significantly influenced green forage yield of grasses and legumes in mixed pasture. Planting of grasses and legumes in 1:2 ratio at 50 cm apart resulted in significantly higher green forage yield of both, grasses and legumes, as compared to other planting patterns. Significantly, higher green forage yield of both grasses and legumes was also obtained at 70 days harvest interval as compared to 45 and 95 days intervals (Table 32).

Table 31: Vigour of prominant range grasses at different habitats

Species	Flat				Elevation				Gullies			
	Plant height (cm)	Tussock area (Sq cm)	Total tiller (nos)	Fresh weight/ plant (g)	Plant height (cm)	Tussock area (Sq cm)	Total tiller (nos)	Fresh weight/ plant (g)	Plant height (cm)	Tussock area (Sq cm)	Total tiller (nos)	Fresh wt./ pt. (g)
1. *Cenchrus ciliaris*	30 ± 9.9	154	45	180.8	25 ± 7.9	91.6	50	180.3	67.0±6.63	283.6	71	278.2
2. *Pennisetum pedicellatum*	53.8 ± 9.4	60.9	36	193.5	52.2 ± 6.8	60	26	166.0	54.5±17.9	162.9	31	222.2

Table 32 : Green forage yield of mixed pasture as influenced by planting patterns and harvest frequencies

Treatments	Green forage yield (t/ha)		
	Grasses	Legumes	Total
Planting pattern (Ratio of grass/legume; spacing cm)			
(1:1)50	17.49	4.99	22.48
(1:2)50	18.05	6.64	24.69
(1:1)75	17.03	5.21	22.24
(1:2)75	15.81	6.44	22.25
C.D. 5%	0.73	0.45	0.83
Harvest frequencies (days)			
45	15.72	6.24	21.96
70	17.64	6.05	23.69
95	17.06	5.73	22.79
120	17.94	5.27	23.21
C.D. 5%	0.73	0.45	0.83

Effect of potash on grass-legume interference

Intercrop performance of a mixed pasture of *Chrysopogon fulvus* and *Stylosanthes hamata* was measured during the year using five levels of interference i.e. grass and legume in monoculture and grass and legume with three population mixtures (grass-legume population, 1:1, 2:1 and 1:2) under 3 levels of potash (K0, K30 and K60 kg/ha) in a RBD factorial design. Grass-legume mixture demonstrated yield advantages with the addition of K as relative yield totals (RYT) was 0.92 to 1.0 with no K under different population ratio, which increased and ranged from 1.17 to 1.44 with 30 and 60 kg K/ha in different grass-legume combinations. Relative yield (RY) of legume increased from 0.47 with K0 to 0.53 and 0.61 with K30 and K60 kg/ha respectively in 1:1 mixture. However, RY of grass was not enhanced as it was 0.62, 0.66 and 0.63 with 0, 30 and 60 kg K/ha respectively. Application of K also increased dry matter(DM) in monoculture in both the species. DM yield of *C. fulvus* and *S. hamata* was 7.5 and 3.84 t/ha with K0, which increased to 8.58 and 4.15 t/ha resulting an increase of 14 and 7.5% respectively. Increase in RYT and RY

of legume with the addition of K indicates that there was competitive interference between *C. fulvus* and *S. hamata* as both the species were limited by a common pool of limiting resource. K also plays an important role in the persistance of legume. As regards to total forage yield per unit area, *C. fulvus* gave highest DM yield of 8.58 t/ha with K 60 kg/ha followed by mixture of 2:1 (2 rows of grass and one row of legume) with 8.25 t/ha having 28% of legume component, possibly an ideal combination for livestock feeding.

GRAZING MANAGEMENT

Mixed herd grazing

The treatments of variable stocking rates introduced in the second year were repeated this year in order to assess the impact on shrubs infesting the natural grasslands. The doubling up of the stocking rate showed marked impact on shrubs as reflected in their reduced volumes (Table 33). The reduction in shrub volume followed a linear trend over August to December period and this trend corresponds to the gradual non availability of green herbage and switch over to the browse in the winter months. This trend was more conspicuous in the paddock B, wherein double of stocking rate was introduced. The shrub volume of spiny tall shrubs *viz*., *Acacia catechu, Flacourtia indica* and *Ziziphus xylopyrus* remained unaffected because of two possible reasons *viz*., (i) height beyond the reach of animals specially goats, and (ii) their preference beyond the winter months. It is therefore, recommened that the spiny tall desirable shrubs should be cut before monsoon to an approachable height of grazing animals/lopped and fed.

Both the treatments of the stocking rate were at par in terms of liveweight gain of

Table 33 : Effect of stocking rate on rangeland shrubs

Species	Stocking Rate - A (1 ACU/ha)			Stocking Rate - B (2 ACU/ha)		
	Months					
	Aug.	Oct.	Dec.	Aug.	Oct.	Dec.
	Equalized shrub volume (m^3)					
1. *Carissa spinarum*	0.70	0.77	0.99	0.36	0.27	0.28
2. *Grewia flavescens*	0.96	0.80	0.75	0.50	0.55	0.16
3. *Helicteres isora*	9.02	12.52	13.85	5.40	5.08	4.81
4. *Securinega virosa*	14.01	9.61	11.34	2.13	1.31	0.99
5. *Ziziphus nummularia*	2.78	1.42	1.07	0.52	0.48	0.47

goats. Sheep showed reduction in liveweight and heifers maintained body weight under both stocking rates.

SILVOPASTORAL SYSTEM

Bio-physical Spreadsheet Modelling

In the second year of study , data pertaining to three silvopastoral systems *viz*.; I. *Acacia tortilis* + *Cenchrus ciliaris*, II. *Leucaena leucocephala* + *Panicum maximum* and III. *Hardwickia binata* + *Sehima nervosum* were recorded. Two types of situation *viz*.; within four tree and around single tree in two spacing *viz*.; 4x4, 4x3 m were assessed for quantifying the above and belowground factors responsible for decay function of understorey grass production. The plots were divided into 9 subplots (grids) and in each grid, Photosynthetically Active Radiation (PAR at grass canopy- PAR-C), PAR at grass ground level (PAR-G), Soil moisture, temperature, tree roots at three depths *viz*., 0-10, 10-20, 20-30 cm along with tree growth *viz*., diameter at 20, 130 cm height and crown spread were recorded at the time of grass harvest in October, 1997.

During the Second year, despite unusual weather conditions, it was clear that below ground factors play an important role on the under storey grass production in all the systems studied and following significant relationships were evolved:

SYSTEM I

(Four tree situation)

Spacing 4x4 m

Grass (g /Sqm) = 69.0133 exp.(0.2555** (PAR-C) -0.0032 Crown + 0.1619* SM(20-30))

Adj. R2= 0.3831, R2 = 0.4543

SYSTEM II

(Four tree situation)

Spacing 4x3 m

Grass (g /Sqm) = 51.347 exp.(0.1568* SM(20-30) + 1.9654* Rt. Wt (10-20))

Adj. R2= 0.2920, R2 = 0.3753

SYSTEM I

(Single tree situation)

Spacing 4x3 m

Grass (g /Sqm) = 196.94 exp.(-6.7681* Rt. Wt. (20-30))

r2= 0.1697

Spacing 4x4 m

Grass (g /Sqm) = 0.1988 exp (-0.1100* SM(0-10) + 0.4396** ST(0-10))

Adj. R2= 0.5177, R2 = 0.5177

SYSTEM II

(Single Tree Situation)

Spacing 4x4 m

Grass (g /Sqm) = 219.708 exp (-2.4091** Rt. Wt. (0-10))

r2= 0.2568

SYSTEM III

(Single Tree Situation)

Spacing 4x4 m

Grass (g /Sqm) = 172.777 exp(-2.3808* Rt. Wt. (0-10))

r2= 0.1760

In a four tree situation, both above and below ground factors affected the understorey grass production but in a single tree situation root weight (Rt. Wt.) significantly affected the production as compared with other predictor variables. The pattern of predicted and observed grass production in different grids in two type of situations in the present study will be helpful in future modelling of under storey grass production for different situations (Fig. 19).

Root Studies of Fodder Trees

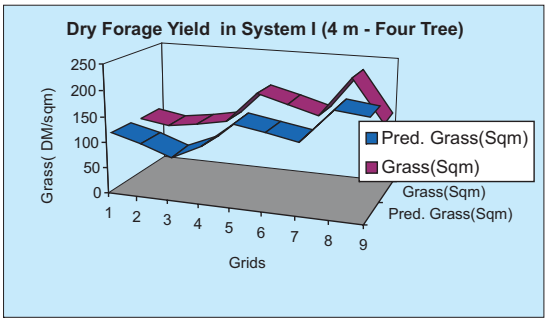
Five silvopastoral systems *viz*., *Acacia tortilis* + *Cenchrus ciliaris, Leucaena leucocephala* + *Panicum maximum, Hardwickia binata* + *Sehima nervosum, Albizia amara* + *Cenchrus ciliaris* and *Albizia lebbek* + *Sehima nervosum* were selected for the root studies. The trees were planted during 1982 and the grass were re-established during July 1997.

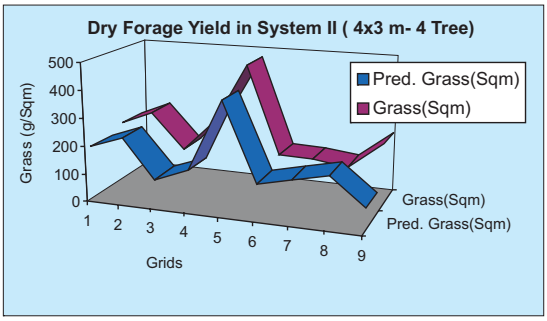
OPTIMIZING LAND PRODUCTIVITY

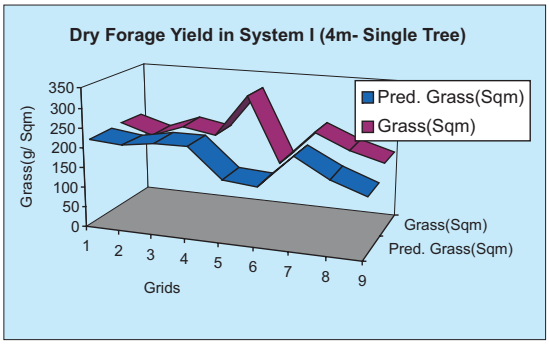
The productivity of silvopastoral systems, designed for different land holdings *viz.,* Small Holding (on 0.2 ha area), Medium Holding (on 0.6 ha area) and Large Holding (on 1.2 ha area), was assessed in the fourth year of the programme. The results obtained in different situations are as under:

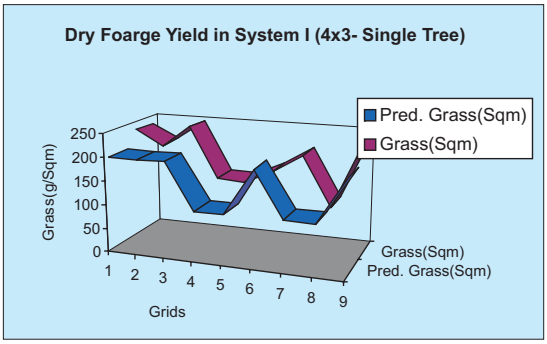
Small holding

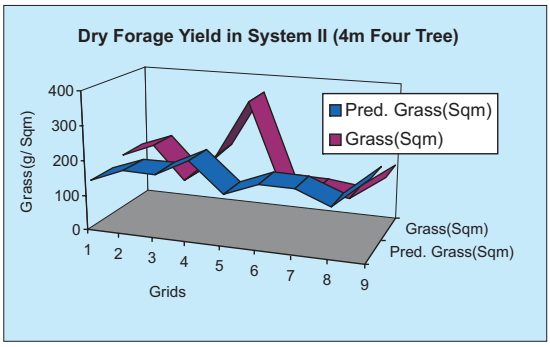
The average pasture production (July-December 97) from the mixture of *Pennisetum* trispecific hybrid (TSH) + Guinea grass + Carribean stylo was 7.99 t DM/ha. On account of four cutrs obtained in both the grass species during July 97, August 97, October 97 and December 97











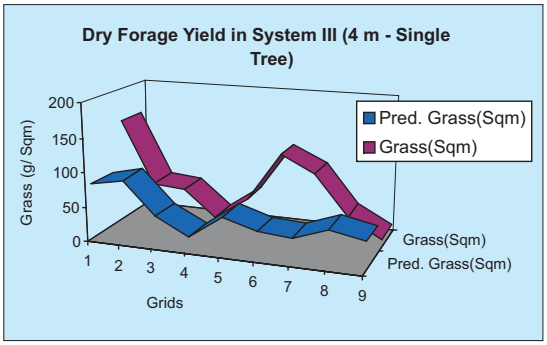


Fig. 19 : Under storey forage yield (Estimated Vs Observed) in the three systems

and harvestisng of grasses close to ground in December 97 cut, much higher production level was achieved during this year when compared to the previous year.

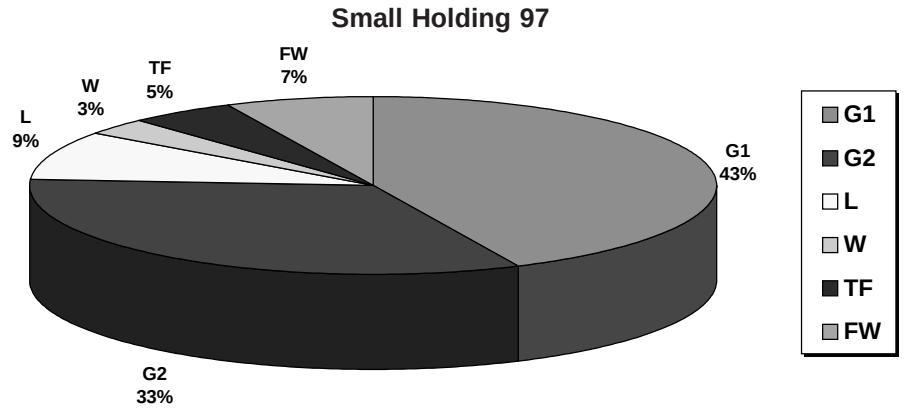
The average leaf fodder and fire wood production from pruning the trees of *Leucaena leucocephala* var. K636, *Acacia nilotica, Dalbergia sissoo, Azadirachta indica* and *Ziziphus* and by maintaining leucaena hedges (at 60 cm height) was 0.456 and 0.644 t DM/ha, respectively. The leaf/stem ratio in the pruned and hedge material was 0.846 and 0.621, respectively. Thus, the ground vegetation (including weed) and trees provided about 88 per cent and 12 per cent of the total biomass produced by the system (Fig. 20).

Medium holding

The average pasture production during July - December from natural *Sehima - Dichanthium* with introduction of Carribean stylo was 3.48 t DM/ha. This year production level was higher by about 12 per cent when compared to the previous year. The average leaf fodder and fire wood production from pruning the trees of *Dalbergia sissoo, Azadirachta indica* and *Ziziphus* and by maintaining Leucaena hedges (at 60 cm height) was 0.253 and 0.497 t DM/ha, respectively. The leaf/stem ratio in the pruned and hedge material was 0.473 and 0.567 respectively. Thus, the ground vegetation (including weed) and trees provided about 83 per cent and 17 per cent of the biomass produced by the system (Fig 21).

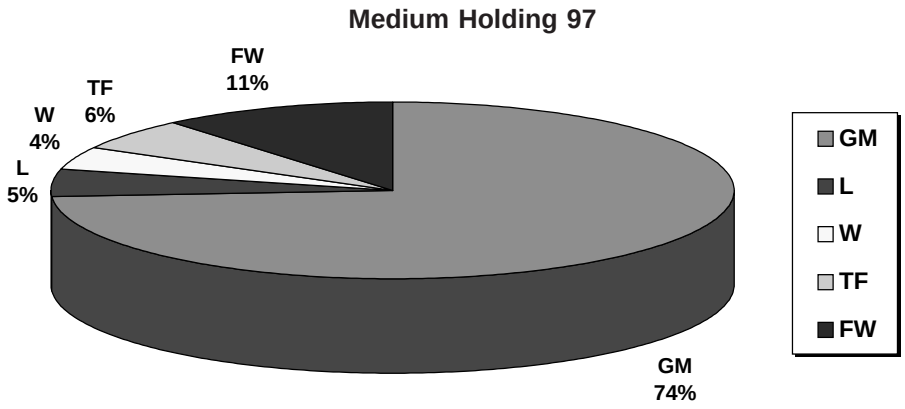
Large holding

Average pasture production during April 97 - December 97 from the mixture of



G1 = TSH ; G2 = Guinea grass; L = Carribean stylo;
W = Weed; TF = Top feed FW = Fire wood

Fig. 20 : Biomass contributed by different system components in small farm situation



GM = Grass mixture of *Sehima* and *Dichanthium*; L = Carribean stylo;
W = Weed; TF = Top feed; FW = Fire wood

Fig. 21. Biomass contributed by different system components in medium farm situation

Cenchrus ciliaris + *Dichanthium annulatum* + *Carribean* stylo + *Leucaena* sowing was 4.15 t DM/ha. On account of three cuts during April 97, August 97 and November 97, higher production level was achieved during this year when compared to the previous year.

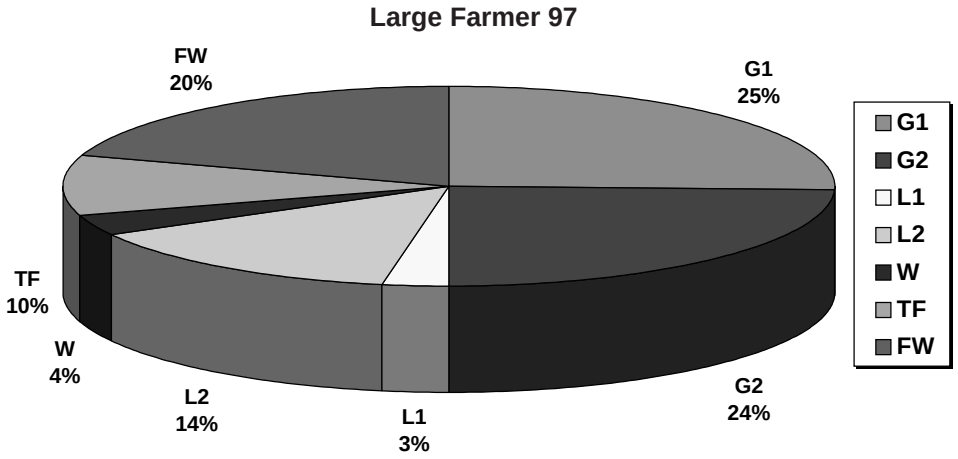
The average leaf fodder and fire wood production from pruning the trees of *Leucaena leucocephala var. K8, Dalbergia sissoo* and *Acacia nilotica* and by maintaining *leucaena* hedges (at 60 cm height) was 0.57 and 1.17 t DM/ha, respectively. The leaf/stem ratio in the pruned and hedge material was 0.356 and 0.782, respectively. Thus, the ground vegetation (including weed) and trees provided about 70 per cent and 30 per cent of the total biomass produced by the system (Fig. 22).

The single line boundary plantation of a tree mix of 8-10 year old *Acacia nilotica, Hardwickia binata* and *Eucalyptus*, including *leucaena* hedges in between the trees; around the 0.6 ha area; provided an additional yield of 1.29 t DM. About 80 per cent of this yield was obtained through pruning and lopping management of the standing trees and the remaining 20 per cent yield was obtained through cutting management of leucaena hedges.

PRODUCTIVITY AND PATTERNS OF NUTRIENT TURN OVER

Pasture production

In the second year of study, highest weed free pasture production was recorded under the trees of *Hardwickia binata* (2.93 t DM/ha) followed by *Acacia tortilis* (2.86 t DM/ha) and *Albizia amara* (1.13 t DM/ha). On account of lopping man-



G1 = *Cenchrus ciliaris*; G2 = *Dichanthium annulatum*; L1 = Carribean stylo; L2 = *Leucaena* sowings; W = Weed; TF = Top feed; FW = Fire wood

Fig. 22 : Biomass contributed by different system components in large farm situation

agement practiced during the previous year, the pasture production level obtained during this year are higher when compared to previous year. This effect was most pronounced under *Albizia amara* (0.76-2.86 times) as the trees tolerated heavy crown lopping.

Tree biomass

At 24th year, higher bole biomass was recorded in *Hardwickia binata* when compared to similar age plantation of *Albizia amara*. However, because of much higher leaf and pod biomass, higher aboveground productivity was recorded in *Albizia amara* (2.7 - 5.2 t DM/ha/y) followed by *Hardwickia binata* (2.9 - 4.0 t DM/ha/y). Acacia tortilis, at 14th year exhibited aboveground productivity in the range of 2.4 - 3.2 t/ha/y. Higher production of pods was recorded in 14 year old *Acacia tortilis* (0.070 - 0.079 t DM/ha) when compared to 24 year old *Albizia amara* (0.05 - 0.06 t DM/ha).

Litter production

Highest average annual litter production was recorded under 24 year old *Albizia amara* (6.6 t DM/ha) closely followed by *Hardwickia binata* (6.4 t/DM/ha) of similar age. In 14 year old *Acacia tortilis* plantation the average litter production was 4.4 t DM/ha. Highest proportion of leaf (77%) and branch (23%) litter was recorded under *Hardwickia binata* followed by *Albizia amara* (leaf 70%; branch 12%; miscellaneous 18%) and *Acacia tortilis* (leaf 61.3%; branch 16%; miscellaneous 22.7%). Highest mass loss (April - October 97) in leaf litter in field conditions was recorded in *Albizia amara* (34.4%) followed by *Acacia tortilis* (33.2%) and *Hardwickia binata* (29.8%).

Forage Quality and Plant Nutrients

The tree leaf consistently provided higher crude protein (CP) when compared to the pasture component. Among tree species, *Albizia amara* provided highest average CP (16.3%) followed by *Acacia tortilis* (12.2%) and *Hardwickia binata* (8.4%). In grasses, higher nutrients *viz*., nitrogen, phosphorus, potassium and calcium were recorded in aboveground parts as compared to belowground parts. In case of trees, highest nutrients were found in leafy parts followed by roots, branches and bole.

HORTIPASTORAL SYSTEM

Ber and Kinnow based hortipastoral system

Maximum number of trees bearing fruits (66.67) and maximum fruit yield (8.21 t/ha) was obtained when Kinnow were grown with *Sehima nervosum*.The difference with other treatment combination was statisfically non significant.

In both the systems maximum pasture production was obtained when grass and legume was grown together, with fruit trees, however, the differences were statistically non significant (Table 34).

Pasture production reduced due to the presence of trees. The loss was, however, compensated if stylo is added. Production of stylo was low but it helped in increased production of grasses.

Aonla based hortipastoral system

Experiment was continued in the sec-

Table 34 : Fruit and pasture production under hortipastoral system

Treatment combinations		Fruit yield (t/ha)	Pasture production (DM t/ha)
Ber based system			
Cenchrus	-with trees	*	3.11
	-control		2.46
Stylo	-with trees	*	1.85
	-control		2.86
Cenchrus + Stylo	-with trees	*	3.31
	-control		2.81
CD at 5%			NS
Kinnow based system			
Kinnow alone		6.42	-
Sehima natural		-	2.83
Sehima natural + trees		8.21	2.54
Sehima natural + trees + Stylo		6.11	3.65
CD at 5%		NS	NS

* Data will be recorded in Feb./March, 1998

ond year with seven treatments (T1F0 - Aonla pure, T2F1- Aonla + *Dichanthium* + 60 kg N/ha, T3F2 - Aonla+ *Dichanthium* + 75 kg N/ha, T4F3 - Aonla + *Dichanthium* +90 kg N/ha, T5F1 - *Dichanthium* +60 kg N/ha, T6F2 - *Dichanthium* + 75 kg N/ha and T7F3 - *Dichanthium* + 90 kg N/ha in a randomised block design.

Cent per cent survival is noticed in all the treatments in the second year of plantation. Maximum height (2.44 m) and collar diameter (3.73 cm) was recorded in treatment T1F0 and T3F2 respectively; whereas increment in height and diameter over previous year was maximum in treatment T1F0 the less increment in the rest treatments over T1F0 might be due to competition with the planted grasses. Pasture production (green) did not show definite trend due to poor establishment followed by gap filling.It ranged from 15.20 to 23.23 t/ha (Table 35).

Drumstick based hortipastoral system

Observations on drumsticks under nursery conditions showed that germination starts from 4th day and continued upto 9th day right from sowing date. However, the maximum germination percentage (70-100%) was found on 7th day almost in all the treatments except in prechilling treatment (T5) where the germination did not take place. Maximum shoot length (46.70 cm) was observed in treatment T3 (KNO_3 -0.1 %). However, cultivar V2 (Black seeded) was found better than V1 (white seeded). Seedlings produced by the seeds with seed coat (W1) attained higher shoot length (43.64 cm) than those seedlings obtained by seeds after removal of seed coat (W2)). Number of branches and leaves per seedling was also maximum in treatment T3 (6.23 and 75.74 respectively. Seedlings obtained by the seeds sown without seed coat was found superior inrespect of both the

Table 35 : Growth of Aonla (*Emblica officinalis* Gaertn.) Cv. NA-7 and herbage yield

Treatments	Growth during 1997		Increment over previous year		Green yield t/ha
	Ht (m)	CD (cm)	Ht (m)	CD (cm)	
T1 F0	2.44	3.55	1.80	2.42	15.20
T2F1	2.13	3.26	1.24	1.89	23.12
T3F2	2.28	3.73	1.43	2.31	22.92
T4F3	2.26	3.44	1.46	2.14	23.23
T5F1	-	-	-	-	15.30
T6F2	-	-	-	-	15.65
T7F3	-	-	-	-	16.02

Table 36 : Effect of different treatments on shoot length (cm), no. of branches and leaves of drumstick cultivars under nursery condition

Treatments/ Cultivars	T1	T2	T3	T4	Av.	W1	W2
Shoot length							
V1	42.90	40.75	43.60	33.58	40.21	40.35	40.06
V2	36.45	41.63	49.80	44.95	43.21	46.93	39.49
Av.	39.68	41.19	46.70	39.27	-	43.64	39.78
No. of branches							
V1	6.40	5.83	6.50	5.63	6.09	6.08	6.10
V2	5.45	5.93	5.95	5.53	5.72	5.60	5.83
Av.	5.93	5.88	6.23	5.58	-	5.84	5.97
No. of leaves							
V1	73.20	68.68	73.30	64.00	69.80	70.99	68.60
V2	66.30	70.95	78.18	67.23	70.67	68.55	72.78
Av.	69.75	69.82	75.74	75.62	-	69.77	70.69

V1 - White seeded cultivars
T1 - Control
V2 - Black seeded cultivars
T2 - GA3 (2000 ppm)
W1 - Seed with coat
T3 - KNO_3 (0.1%)
W2 - Seed without coat
T4 - Thiourea (0.1%)

characters, however, white seeded variety (V1) was found better (6.09) in number of branches and black seeded variety (V2) showed its superiority over V1 inrespect of number of leaves per seedling (Table 36).

Annona based hortipastoral system

Eight cultivars of Annona (*Annona squamosa L.*) *viz*.,*Balanagar*(V1), *Atemoya*(V2), *Atemoya x Balanagar* (V3), Chance seedling (V4), Red seetaphal (V5), Red seetaphal x Pond apple (V6), Islend gem

(V7) and Local Jhansi (V8) were planted with and without pasture during 1996. In the second year of experimentation the growth (height & collar diameter) of all the cultivars was slightly better in treatments having no pasture. The pasture production (*Cenchrus ciliaris* + *Stylosanthes hamata*) did not differ much in any treatment.The average pasture production ranged from 3.70 to 5.02 t/ha (Table 37).

Table 37 : Performance of Annona varities with and without pasture

Cultivars	Plant height		Collar diameter		Pasture yield DM (t/ha)
	With pasture	Without pasture	With pasture	Without pasture	
V1	80.8	134.3	0.98	1.0	4.06
V2	146.3	163.0	2.20	2.7	4.34
V3	90.7	118.9	1.00	2.3	4.37
V4	139.8	177.8	2.50	2.90	4.37
V5	85.5	88.8	1.10	1.2	4.48
V6	108.5	109.3	1.90	2.0	3.70
V7	125.8	155.5	2.00	3.3	4.20
V8	128.0	130.0	2.00	2.4	5.02
Pure pasture	-	-	-	-	4.95

3.4 PLANT ANIMAL RELATIONSHIP

IMPROVEMENT OF LOW GRADE ROUGHAGES

Ammoniation of mature grasses

Dry mature grass was ammoniated with 4% urea and 40% water. A growth and digestion trial was conducted on buffalo heifers for a period of 90 days with following treatments:

T1 : Untreated dry grass + conc.mix.@ 1.3% body wt.

T2 : Ammoniated grass + conc.mix. @ 1% body wt.

T3 : Ammoniated grass + conc.mix @ 0.5% body wt. + CP through *Leucaena leucocephala* supplementation equivalent to 0.5% body wt.

Chemical composition of offered feed *viz*., untreated grass, ammoniated grass and *L.leucocephala* leaves revealed 3.39, 6.82 and 20.90% CP, ; 8.57, 9.89, 8.40% total ash, ; 1.12, 1.10, 4.08% EE, ; 43.49, 46.88 and 19.43% CF, ; 43.43, 35.31 and 47.19% NFE, ; 77.11, 77.27, 47.23% NDF,; 47.12, 52.60, 23.03% ADF, ; 39.63, 44.42, 14.43% cellulose, ; 30.00, 24.64, 19.24% hemicellulose, ; 7.45, 8.17, 8.60% lignin, and 2.56 , 3.95% and 8.00% acid insoluble ash, respectively.

Dry matter digestibility was found higher in T2 (60.80%) than T3 (55.56%) and T1 (55.26%). Similarly, digestibility coefficients of nutrients namely OM, CF, NFE were found higher in T2 (63.63, 63.36 and 61.96, respectively) than T3 (59.53, 59.83 and 60.23, respectively) and T1 (57.53, 52.00 and 59.40, respectively) whereas digestibility coefficient of EE was higher in T1 (78.29) than T2 (76.50) and T3 (66.96). DCP did not differ amongst treatments (6.56 - 6.66%). TDN was higher in T2 (59.70%) as compared to T1 (55.10%) and T3 (55.73%). Similarly, dry matter intake (kg/100 kg b.w.) was slightly higher in T2 (2.95) than T1 (2.69) and T3 (2.50). Blood metabolites namely blood urea, ammonia-N, serum protein, albumin, globulin and glucose levels were 28.60, 1.40, 6.92, 3.96, 2.96 and 55.74%, respectively in T1; 30.60, 1.40, 7.10, 4.00, 3.10 and 56.13% respectively in T2, and 30.50, 0.93, 7.43, 4.27, 3.16 and 56.07%, respectively in T3. Live weight gain as visualized by growth curve(Fig. 23) showed an upward trend in treated groups(T3 and T2) than untreated group (T1).

NUTRITIONAL EVALUATION OF FORAGES

Varietal evaluation

Two improved varieties of sorghum *viz*. HD-15 and JS-10 were nutritionally evaluated against a check variety, HC-136.They were harvested after 75 days of sowing and then conserved as silage. The representative samples of green fodder from each variety were also collected for estimation of nutrient contents. The CP and total ash

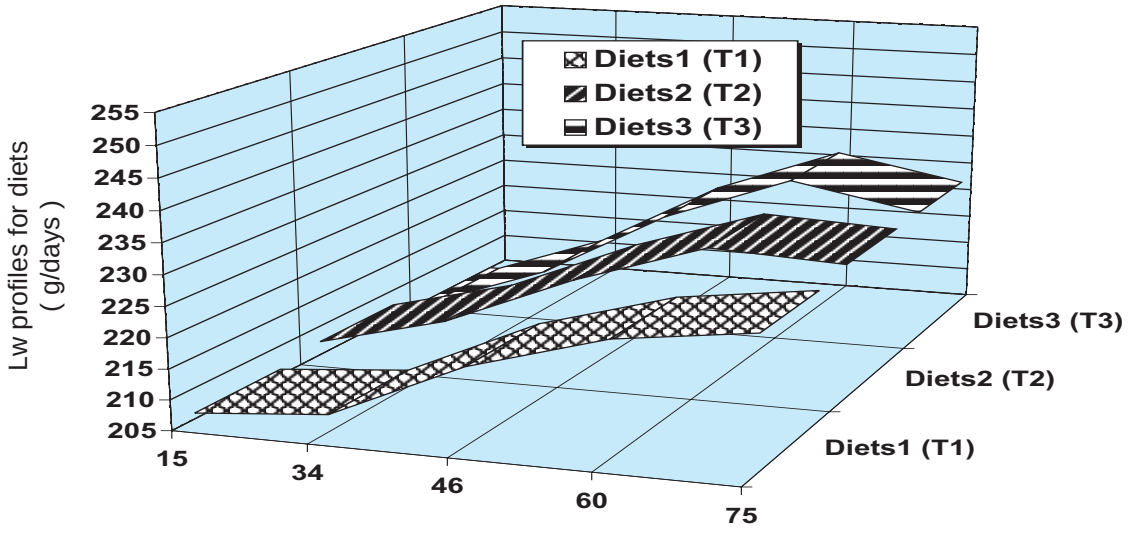


Fig. 23 : Buffalo heifer live weights

content (%) were relatively higher in HD-15 (8.20 & 9.10) as compared to both JS-10 (6.09 & 6.01) and HC-136 (5.38 & 5.86). The NDF, ADF, cellulose and lignin contents were almost similar among the varieties ranging from 65.53 to 67.69, 35.35 to 37.50, 29.14 to 32.32 and 3.83 to 4.48%, respectively. However, nutritive value of the varieties will be evaluated as silage in growing animals.

Fibre-macro minerals interaction

Experiment was conducted to study the effect of different levels of fibre (NDF) on the availability of macro minerals and milk production in eight lactating crossbred cows divided into two groups. Cows in group I and II were fed low and high fibre diets consisting of early and late cut grass + stylo hay along with concentrate mixture, respectively to meet the requirement. Results showed that intake of DM (8.0 and 7.9 Kg/d) did not vary significantly, whereas NDF intake was higher ($P < 0.05$) in group II (5.03 Kg/d) as compared to group I (4.14 Kg/d). Milk yield as well as digestibility of nutrients were almost similar in both groups. Blood mineral status was also similar in two groups. Thus different levels of NDF intake had no effect on macro mineral status and milk yield.

Indigestible DM and NDF as marker

The indigestible DM (IDM) and NDF (INDF) were estimated in feed and faeces of 12 crossbred rumen fistulated cattle fed on different rations following incubations of feed and faeces for 10 days in the rumen using nylon bag technique. The present faecal execretion of IDM and INDF were 103.96 + 3.12 and 95.26 + 3.64, re-

spectively. The correlation between intake and excretion of IDM and INDF were 0.9192 and 0.9176, respectively. It is concluded that IDM and INDF can be used as internal marker.

FEEDING SYSTEM FOR DAIRY ANIMALS

Twenty one healthy crossbred female calves of 6-13 months age were divided into 3 groups (G1, G2 and G3) of 7 animals each . Calves of G1 groups were fed a concentrate mixture containing 50% barley grain which was replaced (up to 80%) with wheat bran in concentrate mixtures of G2 and G3 groups. While concentrate mixtures of G1 and G2 groups contained groundnut cake (GNC) as protein sources, was completely replaced with mustard cake (MSC) in G3 groups. Calves were fed these three different concentrate mixtures under respective groups to meet 60% of the protein requirement (NRC, 1989). The rest 40% of the protein was met through berseem hay. Wheat straw was given ad.lib. to all the calves. The feeding was continued for 120 days.

The average daily dry matter intake (Table 37), digestibilities of DM, OM, CP, EE, NDF, ADF and cellulose and blood profile namely blood glucose,plasma protein and urea did not vary amongst the dietary groups ranging from 63.90 to 65.50 mg/100 ml, 8.22 to 8.72 g/100 ml and 16.41 to 20.19 mg/100 ml, respectively.

The study revealed that neither the low grain rations nor the variation in protein source did elicit any effect on DMI, nutrient

Table 37 : Performance of crossbred female calves fed with varying levels of grain and source of protein

Particulars	G1	G2	G3
Dry matter intake			
g/d	3041±465	3066±470	3018±492
Kg/100 kg b.wt.	2.93±0.11	2.81±0.03	2.76±0.13
g/kg W 0.75	92.94±4.96	90.26±3.78	88.92±6.83
Digestibility (%) of nutrients			
DM	63.02±1.66	59.79±0.40	62.45±1.29
CP	67.50±1.66	64.82±0.83	64.87±1.06
ADF	42.82±3.13	41.57±1.27	41.50±4.59
Growth performance			
Total wt.gain(kg)	53.85±4.80	53.00±4.23	46.14±5.531
Average daily gain	448.40±40.07	441.50±35.28	384.30±46.09
Blood profile			
glucose(mg/100ml)	64.00±0.64	65.50±2.03	63.90±2.31
Plasma protein(g/100ml)	8.72±0.48	8.22±0.22	8.22±0.19
Plasma urea nitrogen (mg/100 ml)	17.90±1.48	20.19±1.12	16.41±0.63

digestibility, growth and blood metabolites in growing female calves fed forage based rations. A moderate level of growth (400 to 500 g/day) can be sustained in crossbred female calves (body weight about 110 kg) through feeding of about 1.5 kg of low grain concentrate mixture, 1.25 kg of berseem hay and 0.75 kg of wheat straw.

CONSERVATION OF FORAGES

Silage

Tri-specific hybrid (TSH) and Guinea grass (Gu) were harvested after about 35 days of first rain (Ist cut), followed by 30 days (IInd cut) and 40 days (IIIrd cut), respectively and were divided into two parts. One part was ensiled as such and the other was wilted in shade for 24 h in Ist and IInd cut and for 48 h in IIIrd cut and then ensiled in 500 ml glass silos (laboratory silo). Similarly for studying the effect of maturity on silage quality, a portion of the material at the time of Ist cutting (after 35 days of onset of monsoon) was left standing and was cut after 65 days. The height of the plant was about 1.0 m at 35 days of growth. This was also ensiled freshly as well as after wilting.

Wilting in general increased buffering capacity (20.4 vs 22.4 in Gu and 21.6 vs 34.0 in TSH) and decreased the water soluble carbohydrate contents (2.10 vs 1.53 in Gu and 2.92 vs 1.93% in TSH). Rate of reduction in CP content in Gu was more steep (11.96 I, 12.22 II and 6.57 III) as compared to TSH (13.87 I, 15.83 II and 10.34% III).

Wilted silages were good in smell, friable in texture and yellowish green in colour whereas unwilted silages were not good in smell.

Little increase in the pH content due to wilting was recorded in both the crops and consequently acidity was reduced .In general % NH3 of total N was higher in all the silages.Wilting increased lactic acid while decreased acetic acid,, butyric acid and alcohol contents. One day wilting has improved the quality of silage to a great extent.

Hay

Six kilogram of regrowth of guinea and tri-specific hybrid (IV Cut) were harvested in the Ist week of December and were spread under shade in an area of 1.43 m^2 (130 x 110 cm) for hay making. Dry matter was recorded at frequent intervals.

After eight days of drying the material was put in gunny bags and kept without tying the open end of the bag in stack to see the development of fungal growth of such a high moisture content. After about one month of storage, visual observation revealed that there was no fungal growth. The colour of the hay was green and dry matter was more than 82% in both the grasses. Rate of drying was higher in Gu as compared to TSH.

TREE AND SHRUBS AS ANIMAL FEED

Feed deterrents in shrubs

In continuation of earlier work reported

on local range shrubs it was found that the condensed tannin was less than 5% in all the shrubs except in *B.recemosa* (13%) and *G.spinosa* (6.5%) during January. The biochemical assessment of tannin in leaves of these shrubs indicated that tannin in tannin-protein complex were maximum during January to March *viz*. 0.48 - 0.7% (*E.aspara*), 0.54 - 0.23% (*H.isora*), 1.25 - 1.54%(*S.virosa*), 1.2 - 1.74% (*G.flavescens*), 2.38 - 3.87%(*G.spinosa*), 0.267-1.05% (*F.indica*) and 1.85 - 2.5%) (*B.racemosa*). The protein content in tannin-protein complex was 12.7 - 20.25% (*E.aspara*), 22.9 - 15.6% (*H.isora*), 16.1-19.7% (*S.virosa*), 9.3-6.3%(*G.flavescens*), 56.19-36.4% (*G.spinosa*), 26.8 - 12.3% (*F.indica*) and 44.5-64.5% (*B.racemosa*). The crude protein in leaves round the year ranged between 18-11% (*E.aspera*), 19-12% (*H.isora*), 28-10%(*S.virosa*), 21-11% (*G.flavescens*), 16-9% (*G.spinosa*), 17-11% (*F.indica*), 16-10% (*B.racemosa*).

Feeding value

Two groups of barbari goats and Mujaffarnagari sheep consisting of four male in each were fed fresh leaves of *Malia azadirach* as a sole feed for 30 days. At the end of feeding digestibility cum metabolism trial was conducted. Average DM intake was 355 and 346 gm/h/d in goat and sheep, respectively. DM intake percent of body weight was 2.33 kg in goat and 1.79 kg in sheep, which differed significantly. However, DM digestibility was not significantly different among the groups (64.07 vs 64.15%). Animals also maintained their body weight during the trial period.Biochemical profile of blood showed serum protein,albumin, globulin and creatine 6.21 6.41 g dl^{-1} ;3.16 and 2.93 g dl^{-1};3.05 and 3.48 g dl^{-1} and 0.74 and 0.61 mg dl^{-1} in goat and sheep, respectively.Creatine kinase activity was higher (64.52 I.U./L) in goat than sheep (57.59 I.U./L).

Non-conventional forages

Five non-conventional forages were collected during mid July and September. The chemical composition of these forages is presented in table 38. Dried sample of *Helicteres isora* was used for determination of in vitro NH_3-N production (mg/100 ml) which varied between 5.6 to 9.8 mg/100 ml SRL.

Table 38 : Chemical composition on % DM basis

Forages	CP		NDF		ADF		TA		ADL		ADF-N	
	July	Sept.	July	Sept.	July	Sept.	July	Sept.	July	Sept.	July	Sept.
Helicteres isora	20.25	16.97	42.60	43.17	28.75	25.84	10.69	9.88	6.97	6.48	0.34	0.35
Albizia lebbek	19.10	-	52.66	-	40.98	-	6.86	-	15.20	-	0.49	-
Securinega virosa	22.38	16.70	21.45	25.83	15.00	18.34	8.54	7.92	2.41	2.17	0.23	0.16
Grewia flavescens	24.00	18.87	52.50	52.76	28.25	34.40	12.23	7.83	7.60	9.83	0.26	0.30
Ehretia aspara	17.41	19.68	33.98	33.33	28.48	26.51	9.12	13.78	6.98	5.45	0.53	0.45

3.5 SEED TECHNOLOGY

SEED PRODUCTION TECHNOLOGY

Clitoria

The effect of KNO_3 and $CuSO_4$ on seed yield of *Clitoria ternatea* with four levels of potassium nitrate (0,2,4 and 6 kg/ha) and four levels of copper sulphate (0,0.5, 1.0 and 1.5 kg/ha) revealed that the application of potassium nitrate @ 2 kg and 4 kg/ha improved the seed yield (453.76 to 508.44 kg/ha) over the control (355.91 kg/ha) and the foliar application of $CuSO_4$ @ 1.0 kg/ha enhanced the seed yield (492.56 kg/ha). Lowest seed yield was obtained (420.07 kg/ha) in the control. The seed crop of *Clitoria ternatea* responded upto 4 kg KNO_3/ha. Highest stover yield (7.30 t/ha) was obtained with the foliar application of 4 kg KNO_3/ha.

Setaria

The effect of four levels of nitrogen (0, 40, 80 and 120 kg N/ha) and three levels of cutting management (clipping, cut once and uncut) was studied on seed production in *Setaria sphacelata* cv. nandi. Highest seed yield (38.23 kg/ha) was obtained with 120 kg N/ha which was at par to 80 kg/ha (37.53 kg). Lowest seed yield (32.28 kg/ha) was obtained in the control (no nitrogen). However, the highest seed yield (40.25 kg/ha) was obtained with uncut crop followed by clipping (35.13 kg/ha) and lowest with one cut (32.32 kg/ha). Maximum stover yield (18.80 t/ha) was obtained with the application of 120 kg N/ha.

Dichanthium

The four levels of nitrogen (0, 20, 40 and 60 kg N/ha) and three levels of cutting management (clipping, cut once and uncut) were tested for seed production in *Dichanthium annulatum* (IGFRI-585). The highest seed yield (38.07 kg/ha) was obtained with 60 kg N/ha which was at par with 40 kg N/ha (37.11 kg/ha) and minimum seed yield (31.9 kg/ha) was obtained in the control. In cutting management schedules the highest seed yield (41.86 kg/ha) was obtained with uncut crop, followed by clipping (35.21 kg/ha) and crop cut once (29.39 kg/ha). Regarding stover yield, the highest (11.3 t/ha) was obtained with 40 kg N/ha.

Berseem

The effect of cutting management, irrigation schedule and exogenous chemical spray on seed production of berseem revealed that last fodder cut taken during first week of March gave highest seed yield (455 kg/ha), followed by second week of March (411 kg/ha) and last week of February (400 kg/ha). As regards irrigation schedule, highest seed yield of 474 kg/ha was obtained when irrigation was given at 7 days after taking last fodder cut and subsequently at flowering stage. The lowest seed yield (360 kg/ha) was recorded when the crop was irrigated two weeks after last fodder cut and at seed formation stage. A significant variation in seed yield was recorded with re-

spect to foliar application of growth hormones and plant nutrients at flowering stage. Tresol (a combination of micronutrient and GA) gave highest seed yield (444 kg/ha), followed by kinetin 50 ppm (427 kg/ha) and GA 100 ppm (395 kg/ha).

Cowpea

Genotypic differences were observed in the seed production potential of two cowpea varieties (Fig. 24). Variety Bundel *Lobia*-1 was the higher seed yielder and produced 406 kg/ha seed, almost double as compared to UPC-5287 (199 kg/ha). Interestingly, the lowest seed rate (15 kg/ha) produced the highest seed (338 kg/ha) which was significantly higher than that obtained with seed rate 25 kg/ha (288 kg/ha) and 35 kg/ha (282 kg/ha).

Panicum

The seed collection in April, August and October contributed 26.4, 21.8 and 51.8%, respectively to the cumulative annual seed yield. Potassium application (all the three levels) before flowering significantly affected the cumulative seed yield . The total annual seed yield was also significantly affected in all the levels of potassium application just before flowering. No significant difference was observed in cumulative fresh fodder yield in all the treatments.

Seed Physiology, Seed Testing & Quality Control

Cowpea

There were significant differences in seed quality in relation to degree of seed maturity in cowpea. The genotype IGFRI 450 (66 days) flowered earlier than EC 4216 (70 days) and IFC 901 (83 days). Both the genotypes EC4216 & IGFRI 450 attained physiological maturity at 20 days after anthesis (DAA) and IFC 901at 26 DAA. Seed quality in terms of potentiality was maximum at physiological maturity. Maximum germinability coincided with maximum dry weight accumulation i.e. EC 4216 (83.33%, 7.84 g); IGFRI 450 (86.66%, 8.13 g) and IFC 901 (73.33%, 7.26g). There were differences between the genotypes for various characteristics studied within each sampling time, however, to visualize the trend of cowpea seed development, the means of all the three genotypes for each character are plotted against sampling time in Fig. 25.

Guar

Both the genotypes (BG-1, and BG-2) attained 50 per cent flowering (74 days) earlier than IGFRI 1019-1 (79 days). Though the seed development process was identical in all the three guar genotypes, as illustrated by gradual increase in fresh weight and dry weight accumulation and concomitant moisture depletion (Fig. 26), but there were genotypic variation in terms of rate of seed development. The rate was relatively faster in BG-1 than BG-2 during early stages of seed development (Fig. 26a & 26b), though both the genotypes attained physiological maturity almost simultaneously *i.e.*, 33 DAA. The genotype IGFRI 1019-1 attained physiological maturity at 38 DAA & its developmental changes are depicted in Fig. 26c.

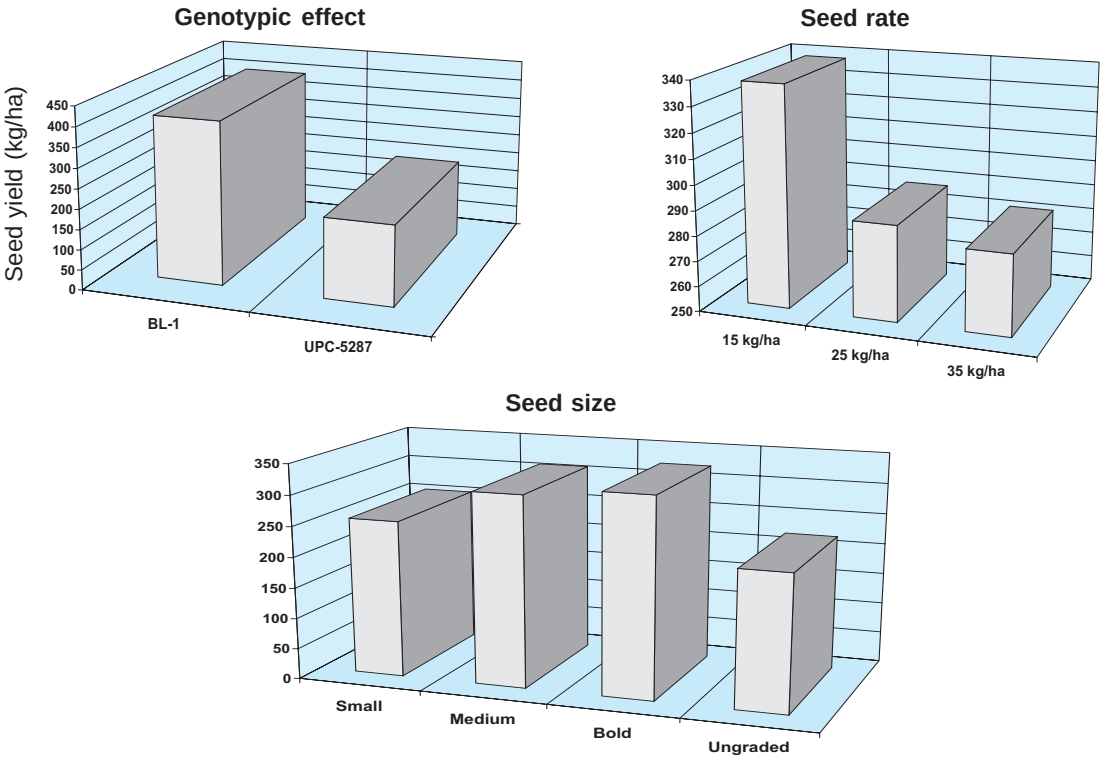


Fig. 24 : Effect of seed size and seed rate on seed yield of cowpea varieties

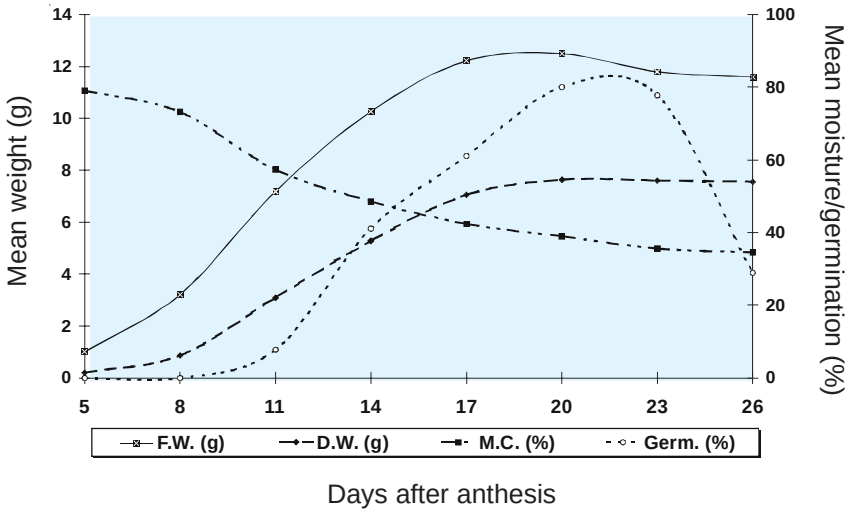


Fig. 25 : Changes in mean fresh wt., dry wt., moisture & germination of developing seeds of three cowpea genotypes at different stages of seed maturity

Fig. 26a : Bundel Guar - 1

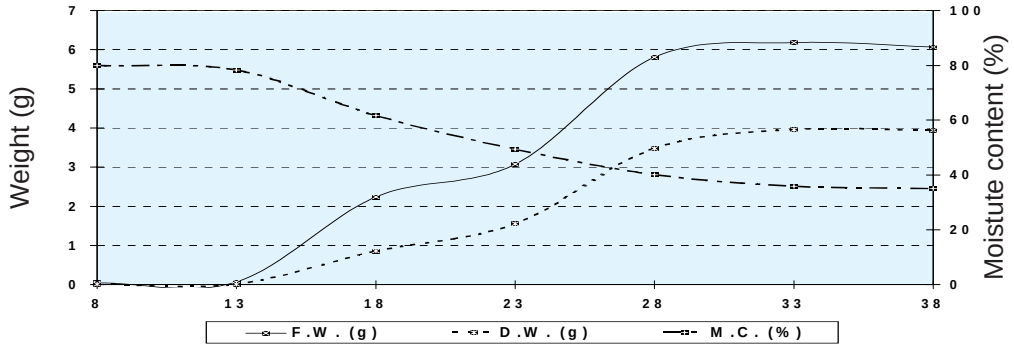


Fig. 26b : Bundel Guar - 2

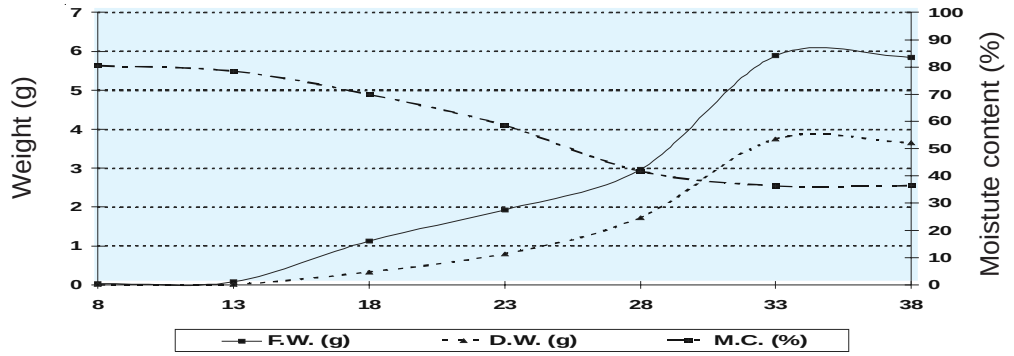


Fig. 26c : Bundel Guar 1019-1

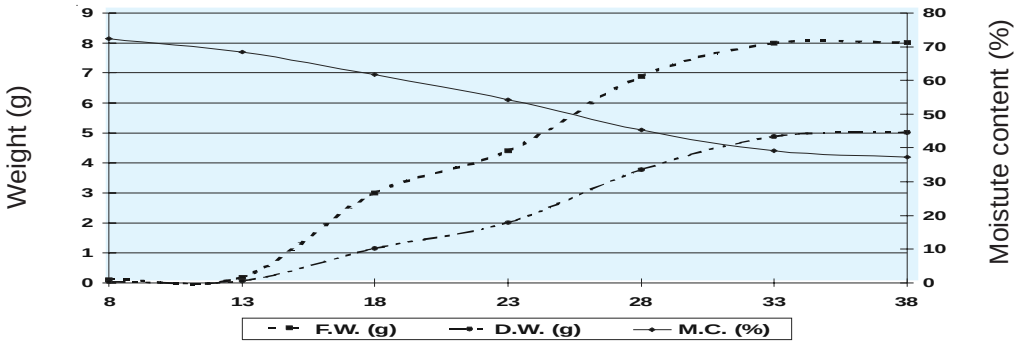


Fig. 26 : Seed development and maturity process in guar

Stylo

Diammonium phosphate (DAP) and muriate of potash (2, 4 and 6 kg/ha), growth hormone (10, 50 and 100 ppm NAA) and their combinations were sprayed on foliage of *Stylosanthes hamata* at vegetative stage and flower initiation stage to assess the effect on morpho-physiological characters and seed production. Morpho-physiological attributes like plant height, number of leaf, leaf area index, dry matter yield and specific leaf weight (SLW) were observed maximum in treated plants. The highest drymatter yield and leaf area production were recorded in the plants sprayed with NAA (10 ppm) + K (2kg) + DAP (2kg) followed by DAP (2kg) + K (2kg). The accumulation of photosynthetic pigments increased by the application of these chemicals, indicating the enhance in photosynthetic activity (Fig. 27). Response of foliarly applied DAP was more as compared to potash and NAA. The results revealed that these treatments increased the photosynthetic efficiency and elemental status of the plants for strengthening the process of source through which potential grain synthesis and seed yield will be enhanced (Table 39)

T1 = Control T2 = 100ppm NAA T3 = 50 ppm NAA T4 = 100 ppm NAA
T5 = 2kg DAP T6 = 4kg DAP T7 = 6 kg DAP T8 = 2 kg Murate of Potash
T9 = 4 kg Murate of Potash T10 = 6 kg Murate of Potash
T11 = NAA + DAP T12 = NAA + K T13 = NAA + K + DAP T14 = DAP + K

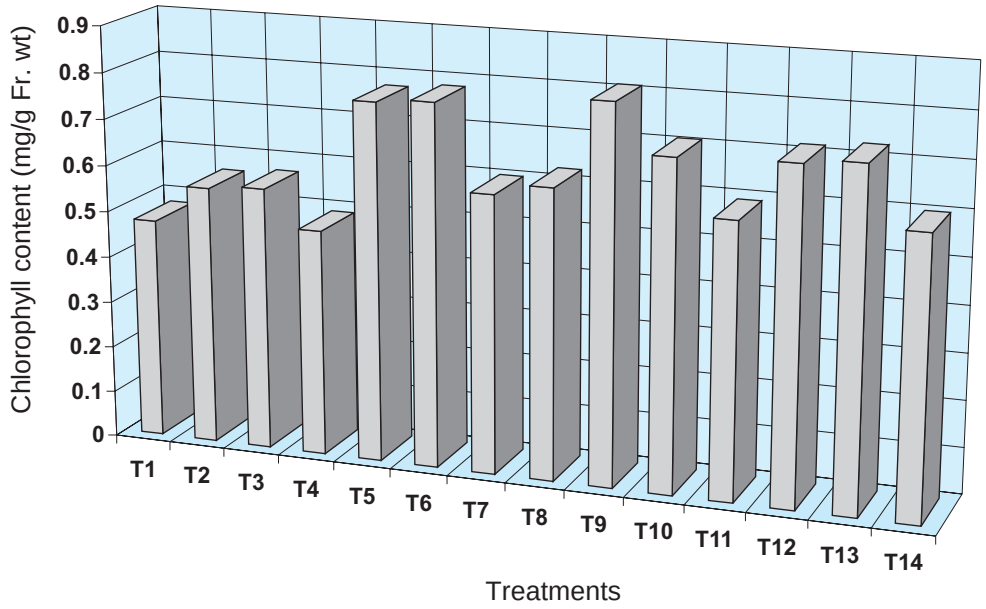


Fig. 27 : Effect of foliar spray on chlorophyll content in stylo leaves

Table 39 : Effect of foliar application of chemicals on growth and morpho- physiology of stylo

Treatments	Plant height (cm)	No. of leaves/p	No. of branches/p	Total Dry wt. (g/m^2)	SLW (mg/cm^2)
Control	56.66	471	16	365.48	53.23
10 ppm NAA	57.33	652	16	305.56	54.2
50 ppm NAA	60.00	855	19	331.64	55.5
100 ppm NAA	59.33	833	17	288.88	53.8
2 Kg DAP	64.66	892	18	368.28	56.3
4 Kg DAP	61.00	867	20	425.04	58.5
6 Kg DAP	66.33	1103	18	420.08	55.0
2 Kg Muriate of Potash	62.66	986	21	364.36	62.0
4 Kg Muriate of Potash	57.33	968	81	320.52	58.1
6 Kg Muriate of Potash	58.66	692	19	383.52	53.5
NAA (10ppm) + DAP (2kg)	57.00	550	19	308.49	52.8
NAA (10ppm)+ K (2kg)	56.00	855	17	371.92	50.6
NAA + K + DAP (10ppm+2kg+2kg)	58.66	1349	22	374.6	51.9
DAP + K (2kg+2kg)	62.66	1310	22	439.8	60.1

The seed quality of *Stylosanthes hamata* was determined by using germination test, conductivity test and potassium leakage test. The seeds of stylo were harvested in January 1997 and stored for eight months in gunny bags were tested for quality characters in different treatments of chemicals *viz*., 100 ppm NAA, 100 ppm GA, PEG - 0.2 Mpa, 1% KNO_3, 1% KH_2PO_4, dilute H_2SO_4 for 1 minute and hot water 60 ^{0}C for one hour at room temperature. Maximum seed germination was recorded with the treatment of dilute H_2SO_4 followed by hot water (60 ^{0}C for one hour). In GA, NAA, PEG, KNO_3 and KH_2PO_4 the germination was half to that of dilute H_2SO_4 and hot water treatments whereas minimum germination was recorded in control (without any treatment). Early germination was observed with the treatment of dilute H_2SO_4, GA and hot water. The bulk conductivity test was also carried out to detect the suitability of seed lot for sowing. In *Stylosanthes hamata* seeds maintained conductivity 22 Mohs indicating that the seeds are suitable for early sowing. As potassium leach out from the seeds is the best indicator of cell membrane integrity in this way the results confirmed that evaluation of seeds

at 2 hour imbibition at 30^0C is suitable for identification of stylo seeds with their vigourness. Therefore it is concluded that dilute H_2SO_4 treatment for one minute and hot water treatment for one hour are the best methods to improve the germination in stylo.

Seed Health and Storage

Lucerne

Studies on control of seed-borne diseases especially *Fusarium* rot, downy mildew and rust in lucerne crop in relation to agronomic practices revealed that early sowing and high agronomic inputs were directly associated with the disease incidence, affecting greater leaf area and yield than the crop sown later with lower inputs. The leaf rust was the predominant disease in all the plots. The pathogens like *Liromyces straitus* (with infection range of 23.3 - 38.5%) and *Peronospora trifoliorum* (range from 11.3 - 22%), affected the seed quality and yield depending on the infected portion of green leaf area. Disease reduced the maximum green leaf area index by 22 - 33%, along with yield reduction due to complete epidemics (upto 46%).

Rice bean

Seed mycoflora of ricebean (*Vigna umbellata*) was assessed to see the frequency of isolates. They were *Macrophomina phaseolina* (11-68%), *Fusarium moniloforme* (2-46%), *F. semitectum* (3-33%), *Curvularia lunata* (2 - 23%), *Alternaria alternatea* (2-14%) and *Aspergillus* spp (3-18%). In all the samples *Macrophomina* and *Fusaria* were found to be most virulent causing pre and post emergence mortality in the seedlings.

Albizia and *Clitoria*

A seed storage experiment was conducted to assess the effect of containers and pesticides on the storage pests and pathogens and storability of *Albizia lebbeck* and *Clitoria ternatea* seeds.

Among the different seed treatments and containers used for storage, seeds stored in plastic jars and polythene bags with seed dressing of Bavistin and Malathion (1:1) @ 1 g/kg retained viability upto 22 months of storage. The untreated seeds of both kinds recorded low viability irrespective of containers used. A progressive increase in seed moisture content (from 10.5 to 15.5.%) was recorded which gradually reduced germination upto 36.75% with 15 months of storage in cloth and gunny bags. In case of plastic containers, seeds retained germination upto 62% in *Albizia* and 80% in *Clitoria* with negligible disease occurrence up to 22 months of storage. Neem leaf powder resulted in high germination and low infestation (3-5.2%) in the beginning but later on it behaved like control. Frequency of fungal flora and beetles (*Callosobruchus* spp) were measured in treated seeds. The seed treatment combination of Bavistin and Malathion (1:1) proved to be effective in polythene and plastic jars against storage fungi and beetle (*Callosobruchus* spp.) damage due to total mortality of the released adults without adversely affecting the germination of these seeds.

The efficacy of plant-origin botani-

cals *viz*., *Acorus calamus*, *Croton tiglium* and Neem kernel extract were ascertained in both categories of seeds for beetle infestation and storage fungi in comparison with the widely used organic fungicides and pesticides for the control of bio-infestation and maintaining high seed germination in *Albizia* and *Clitoria.* Of all the treatments *Croton* and *Acorus* extract @ 1.0 ml per kg seed were found to be unique in providing zero per cent oviposition and controlled the storage fungi and also protected these seeds for over 22 months with least damage. Number of abnormal seedlings after 15 months of seed storage, was significant in other treatments. Seedling root and shoot length declined significantly with the increase of storage period. In control, the infestation varied from 16.5 - 30% with drastic reduction in germination.

The various storage fungi which are effectively controlled by these two treatments of botanicals are *Fusarium moniliforme, Curvularia lunata, Cercospora albizeae, C. ternatea* and *Cladosporium* spp. Application of these botanicals also inhibited the development of major stored grain pests, *viz*., *Callosobruchus chinensis, C. maculatus* and *Bruchidius albizeae.* They inflicted almost 100% mortality to the bruchids and sustained their effect with more than 80% germination in *Clitoria* and 56 - 65% germination in *Albizia* seeds during 22 months of storage.

Biological control of cowpea seed beetle

Callosobruchus maculatus is the most prominent seed damaging pest of cowpea. The population of this pulse beetle is effectively checked by two parasitoids *viz*., *Uscana mukerjii* (Trichogrammatidae : Hymenoptera) and *Dinarmus basalis* (Pteromalidae : Hymenoptera) (Identified at IARI, New Delhi). *Uscana mukerjii* parasitizes eggs of *C. maculatus*. The parasitoid completed its development inside the host egg in 8 days at 25±2°C and 60±5% RH and emerged after cutting a circular hole in the chorion of the host egg under laboratory conditions. Maximum parasitization of host eggs took place within first 24 h of egg laying and declined thereafter. Parasitized host eggs did not hatch. *D. basalis* is a larval-pupal ectoparasitoid of the pulse beetle. Its population was found high in the months of September and October, with parasitisation upto 30%.

3.6 FARM MACHINERY AND POST HARVEST TECHNOLOGY

DEMONSTRATION OF FARM IMPLEMENTS

Demonstration of Improved Implements on Farmers field

During *kharif* 1997, three demonstrations each on fodder sorghum and green gram (moong) were conducted under AICRP on FIM Scheme at Karari and Lakara villages using the following package of improved bullock drawn (BD) implements.

1. BD mould board plough
2. BD disc harrow
3. IGFRI BD channel-cum-bund former
4. IGFRI two row seed drill
5. IGFRI weeder-cum-mulcher
6. Improved sickle.

The performance of the package of implements are given in table 40.

The average green and dry matter yield of fodder sorghum were recorded as 23.3 and 8.16 t/ha respectively using improved implements. For the green gram, the yield of the crop was 0.70, 0.80 and 0.83 t/ha using the improved package of implements against 0.63, 0.65 and 0.66 t/ha by traditional method of sowing using indigenous plough. The average increase in green gram yield was about 20.0 per cent over traditional method of cultivation.

DESIGN, DEVELOPMENT AND TESTING OF FARM EQUIPMENTS AND PROCESSES

Performance of Animal Feed Pelleting Machine

During the study, it was observed that

Table 40 : Performance of improved bullock drawn implements on the production of *kharif* crop

Name of implement	Field capacity (ha/h)	Field efficiency (%)
BD mould board plough	0.04	61
B.D. disc harrow	0.11	60
IGFRI channel-cum-bund former	0.70	64
IGFRI two row BD seed drill	0.11	60
IGFRI weeder-cum-mulcher	0.02	-
Improved sickle (man-h/ha)		
for fodder sorghum	140.0	-
for green gram	160.0	-

reduction in crude protein of feed pellets was due to higher temperature generated inside the pipes. To over come this problem pellet die of 26 mm diameter and 175 mm length was improved in two stages.

i) In first stage, the diameter of pipe at base point was increased from 26-40 mm upto a length of 8 mm by chamfering.This resulted in smooth flow of material with reduced density.

(ii) In next stage, attempt was made to control the density by keeping the base diameter of pipe 40 mm oupto a length of 18 mm, then it was reduced to 29 mm in middle and 26 mm at exit point.This arrangement could provide compressing of material inside the pipe which, in turn, increased the density of feed pellets.

Modification for IGFRI Forage Densifying Machine

Forage densifying machine, developed by IGFRI, was modified to reduce the lateral vibration of the piston driving unit of the machine while compressing the hay inside the cylinder housing at the end of compression stroke. The side play of the wheel gears was minimized by inserting one washer of 6 mm thickness and 250 mm diameter in the outer side of both the wheel gears. Both the wheel gear piers were provided 14 mm countersank and chamfered for proper greasing of the wheel axle. The ordinary nuts were also replaced by high tensile nuts.

A variable speed motor of 15 hp with a speed range of 200-1200 rpm is being installed to vary the number of strokes/ min in the range of 20-60 which is at present fixed at 40 strokes/min. The effect of piston speed (strokes/min) on the density of hay bales will be studied for different types of forage crops grasses and crop residues.

3.7 SOCIAL SCIENCE

FORAGE BASED FARMING SYSTEMS AT FARMERS' FIELD

The study initiated since 1992, has been continued at farmers' field (large, medium and small) at Awas village (Shivpur, M.P.) and Sakrar village (Jhansi, U.P.). The improved forage varieties *viz*., SSG 855 and SSG 988 of multicut sorghum, IGFRI-450 and NP-3 of fodder cowpea, Bundel guar 1 and 2 of fodder cluster bean, Wardan of Berseem and JHO-822 & JHO-851 oats were introduced in the existing cropping system.

The farmers were also motivated to use improved production technology and varieties of crops such as Ganga-5 and Vijay in maize grain, CSH-9 and CSH-5 in grain sorghum, Pusa Ruby and Hybrid in tomato, Jwala in Chilli, Bragg in soybean, JL-24 and Indori in Groundnut, T9 in Urd, T-4 and T-12 in til, WH-147 and RR-21 in wheat, Rachna in Pea, Awarodhi and Radhey in gram (Table 41).

The degraded lands of farmers improved through introduction of silvi-hortipasture and hortipasture systems gave 45.0 to 50.0/ha/

Table 41: Cropping systems and the yield (q/ha) at farmers field during 1997-98

Cropping systems	Yield (q/ha)			
	1993 (base year)		1997-98	
	Kharif	*Rabi*	*Kharif*	*Rabi*
A) Rainfed				
Urd/Moong + Til - Linseed	2.7	1.7	10.5	8.5
Piegon pea + Jowar	4.5	1.5	9.5	-
Sorghum (grain) + cowpea fodder - gram + mustard	-	2.5	8.2	10.8
Sorghum fodder + guar fodder - Lentil	-	2.6	351.0	8.4
B) Irrigated				
Groundnut + til - wheat	7.0	9.5	23.5	25.5
Soybean - wheat	6.5	10.4	18.0	30.6
Maize grain - berseem (G.F.)	8.0	240.0	17.5	830.0
Paddy - pea	7.5	6.5	21.6	18.5
Chilli/brinjal/tomato - oats (G.F.)	7.0	-	108.0	520.0

year dry matter production in comparison to 10.0 q/ha/year (1993). The fruit plants sapling like improved variety of *Emblica officinalis, Psidium guava* and *Citrus aurantifolia* were also planted in the degraded lands. The Jharberi (*Zizyphus numularia*) abundantly found on farmers' land were budded with improved varieties of ber (*Zizyphus mauritiana*) such as Benarsi Karka, Urmron, Seo and Gola which generated additional income and also provided 8.0 to 8.5 q/ha/yr fuelwood through prunning of trees (Table 42).

The present study revealed the increased production of food grains, cash crops and fodder at both sites during 1997-98 as compared to base year (1993).

The final survey was conducted in the Lakara-Karari watershed area and information were collected with respect to the socio economic aspects, including the crops and animal husbandry and also for the village as a whole.

As a result of the operation of the NWDB Project in the Ambabai region, employment was generated to the tune of 2403, 3574, 6149 and 5317 labour days during the year 1991-92 through 1994-95, respectively. It was observed that more labour days were required during the months of July to December every year as compared to the first half of the year. The activities that contributed to this employment generation were mainly trench making, for cattle protection, thala making, field clearing, seedling transplantation, pit digging, insect collection, fertiliser application and sample observation. The income so generated during 1991/92-1994/95 was of the order of Rs. 43,250; Rs. 82,202; Rs. 2,27,513 and Rs. 2,49, 582, respectively.

During the period 1990/91 - 1996/97, the resource use and the asset holding position showed a positive increase owing to the developmental activities of the project in the area. Wells, the main source of irrigation, have increased considerably from 350 to

Table 42 : Yield and economic return of budded ber and grasses at farmers field during 1997-98

Fruit/fuel wood/forage	Yield (q/ha)			
	1993 (base year)		1997-98	
Fruit	3.5	(2808.0)	9.5	(9500.0)
Fuel wood	1.5	(60.0)	8.5	(510.0)
Forage from ber tree	1.5	(180.0)	8.4	(1260.0)
Forage from grasses	8.5	(750.0)	40.0	(2000.0)
Total (Rs.)		(3198.0)		(13270.0)

Figures in parenthesis indicate income in Rs./ha.

467 registering a 33 per cent rise during the period. Likewise, the possession of assets like tractors, diesel engines, threshers, harrows, cultivators increased to around 7, 400, 16, 7 and 7, in 1996-97 as against an initial number of 4, 300, 4, 4 and 4 in 1990-91 respectively.

PARTICIPATORY RESEARCH AND ADOPTION OF INNOVATIONS

The farmers of village Etora of Tehsil Moth situated at 42 km from Jhansi were mobilized and sensitized. The PRA exercises were conducted on crops including vegetational resources and their preferences and livestock feed and fodder resources.

The topography of the village is highly undulating having 150 houses of different castes and majority of them are scheduled castes/tribes and backward. The most of area is irrigated by canal followed by water wells. The details of crops/vegetation and feed and fodder resources are mentioned in table 43 and 44 respectively.

The farmers have 110 number of cows, 48 number of buffaloes, 100 number of

Table 43 : Common animal feed and fodder resources prevalent in the village

Animals	Straw	Green fodder/ fresh stalk	Concentrate	Cakes
Cows, buffaloes and drought animals	Wheat Gram Peas Urd (Blackgram) Moong (Green gram) Groundnut Arhar (Pigionpea) Soybean Masoor (Lentil)	Bajra (Pearl millet) Jowar (Sorghum) Berseem Leaves of mustard Biomass of *Zizyphus numularia* & Kutti of Ootkatara	Barley Dalia, Bajra Dalia Wheat Dalia Arhar (Pigionpea)	Mustard Groundnut Til (Sesamum) Castor
Goats and Sheep	Grazing & leaves of Deshi Babool, Beri, Neem, Reonja, Khair, Oomer, Khua and Kardhai	Pods of Dakshini babool Deshi Babool Reonja	-	-

Table 44 : Preferences of farmers for crops, trees and grasses (vegetation) resources in Etora village

Crops			Trees				Grasses	Vegetables	Prefer-
Kharif	*Rabi*	*Zaid*	Timber	Fuelwood	Fodder (top feed)	Fruits			ences
Groundnut & Urd	Wheat	Water melon & Musk melon	Mahua	Dakshini Babool	Pipal	Mango	Mussel	Potato	I
Jowar & Arhar	Peas	Pumpkin & Bottle gourd	Neem	Chhivla	Oomer	Guava	Kel	Onion	II
Soybean & Til	Gram	-	Chirol	Desi Babool	Beri	Aonla	Hiran-Khuri	Tomato, Ginger, Brinjal, Turneric, Rataloo, Coriander, Radish, Carrot, Lady finger, Garlic	III
Bajra & Moong	Masoor (Lentil) & Taramira	-	Desi Babool	Chirol	Neem	Neemboo	Silmili	-	IV
Ronsa & Moth	Mustard	-	Mango	Kardhai	Kang	Papaya	Gunner	-	V

oxen, 152 number calves, 300 number of goats and 800 number sheep in Etora village.

ECONOMIC FEEDING SYSTEMS

For the above study, two tehsils (first stage sampling unit), Karera and Shibpuri of Shivpuri district have been selected. From Karera, two villages (second stage sampling units) namely, Awas and Barkuwan and two villages from Shivpuri tehsil namely Surwaya and Kota have been selected.

The preliminary survey of 80 households in Awas village, 90 households in Barkuwan, 200 households in Surwaya and 150 households in Kota village was done.

SAMPLING TECHNIQUES

A uniformity trial on maize for fodder was laid out on uniform piece of land of size 30 m x 30 m, during rainy season of 1997 at FD block of CR Farm. The harvesting was done at 50% flowering in the units of 1m x 1m, after leaving border areas of 3 metre size in both the directions to eliminate the boarder effect. In all 576 units (24 x 24) were taken for the study. The CV values of plot yields decreased with the increase in plot size in either direction. The average CV values in plot yields of various size of plots were also be worked out, and it was observed that, these values decreased gradually from 57.49% to 3.40% with the increase in plot size $1m^2$ to $144m^2$, this decrease was observed more rapid with an increase in plot size from $1m^2$ to $12\text{-}16m^2$, thereafter the rate of decrease was slower. In general, shape of the plots do not effect the CV values, but in larger size of plots (more than $48m^2$), the CV values between different possible shapes differ significantly.

The relationship between average CV (Y) and plot size x m^2) was ound to be of the form $Y = ax^{-b}$ and gave a very good fit which is shown below :

$$Y = 57.2956\ x^{-0.3967} \quad R^2 = 99.43$$

The modified equation, taking into acocunt the shape of the plot. $Y = ax_1^b\ x_2^b$, where, x_1 and x_2 are the lengths of the polts, respectively, in the direction from N-S and from E-W, was also fitted and is projected here :

$$Y = 59.5193\ x_1^{-0.3442}\ x_2^{-0.4857} \quad R^2 = 91.35$$

3.8 REGIONAL RESEARCH CENTRE, AVIKANAGAR

CROP IMPROVEMENT

Initial varietal trial in fodder Bajra

Eight genotypes namely PCB-155, Giant Bajra, APFBH-1, APFBH-2, FBC-16, FBC-17, APFB-14 and DRSB-6 were evaluated along with two checks, UUJ-IV-M and FMH-3. Though some entries (FBC-17, DRSB-6,FBC-16 and APFBH-2) showed higher green forage and dry matter yield as compared to check UUJ-IV-M, but no entry could exceed the performance of the check, FMH-3. However, APFBH-2 showed highest green forage yield and FBC-16 yielded highest dry matter.

Advanced varietal trial in cowpea

Advanced trial of cowpea was conducted for six entries (UPC-603, UPC-951, UPC-952, UPC-953, IFC-9502 and IFC-9503). All the genotypes, except UPC-953, had higher green forage yield and dry matter than the check, UPC-5286, and no genotype showed better performance than Bundel Lobia-1.

Evaluation of bajra germplasm

Five germplasm lines forage bajra collected from ICRISAT, Hyderabad were evaluated. IP-14911 and High tillering gene pool performed better as compared to other genotypes. (Table 45).

ROLE OF VAM FUNGI

Berseem

Response of berseem to VAM fungi and levels of phosphorus revealed that there was progressive increase in the fresh and dry fodder weight of the berseem var. Wardan with the increase in levels of P over the control. Increase in both fresh (32.85%) and dry weight (42.04%) was observed when the plants were inoculated

Table 45 : Mean of forage yield contributing traits in bajra

Genotypes	Tillers per plant	Pl. ht. (cm)	Panicle wt.(g.)	Dry wt. (g.)	Fresh wt. (g.)
IP-12070	7.23	158.20	25.30	135.80	485.50
High tillering gene pool	21.76	130.15	10.18	122.56	516.04
IP-14911	4.32	270.60	42.16	119.34	527.58
IP-3122	6.18	157.12	15.20	50.18	235.97
IP-17862	4.54	139.32	15.62	30.12	121.50

with VAM and supplemented with P-40 levels. The per cent root colonisation was not affected by the addition of P.

Response of berseem to FYM, VAM and leaf litter showed that the combined inoculation of three components signifcantly (P<0.05) increased the green and dry fodder yield of berseem with no adverse effect on % root colonisation.

Lucerne

Interaction between VAM, Rhizobium and phosphorus in lucerne was studied. Inoculation of VAM in presence of Rhizobium and phosphorus (P-40) significantly (P=0.05) increased the green and dry fodder yield of lucerne. The presence of both the organism together mutually enhanced each others efficiency. The per cent root colonisation and no. of nodules as well as the nutrient contents increased by the presence of these compoents.

Response of lucerne to VAM fungi and levels of Phosphorus revealed significant increase in green and dry fodder yield in the combined inoculations of VAM with P-40 or P-80 levels. However, maximum increase was recorded at P-80 levels. Similarly, the P and N content of plants was maximum at highest levels of P as in case of berseem.

Response of lucerne to FYM, VAM and leaf litter was studied. The data presented in table 46 indicated that the combination of all the three components simultaneously increased the biomass significantly over the control and other treatment. However, all other treatments were at par.

Cowpea

Effect of cellulose amendments on VAM - Rhizobium - nematode interaction in cowpea var. Bundel lobia-1 revealed that there was significant increase in plant growth parameters with presence of *G. fasciculatum* in combination with *Rhizobium* or *cellulose*. The adverse effect of nema-

Table 46 : Effect of leaf litter (LL), FYM and *Glomus fasciculatum* (GF) on the growth of lucerne

Treatments	Green fodder wt. (g)	Dry fodder wt. (g)	P. Content (%)	N. Content (%)	Available P kg a.i. in soil	% root colonisation
Control	7.796	1.123	0.710	2.54	11.25	-
FYM	8.156	1.65	0.141	3.08	12.37	-
Gf	8.623	1.230	0.129	3.00	14.69	48
LL	7.863	1.123	0.131	2.79	12.19	-
FYM + GF	9.326	1.396	0.152	3.23	17.98	49
FYM + LL	8.653	1.389	0.143	2.92	15.70	-
FYM + GF + LL	11.820	1.555	0.152	3.43	18.73	51
C.D. 5%	1.05	0.012	-	-	-	-

tode was mitigated by the presence of VAM. The *Rhizobium* nodulation and % root colonisation was not affected by the presence of *nematode*. However, the no. of galls produced by the nematode was considerably affected by the amendment of cellulose/ VAM.

The presence of yeast culture live or dead in combination with VAM/*Rhizobium* significantly increased the plant growth parameters. However, the no. of Rhizobium nodules produced was not affected by the presence of dead or live yeast, as per cent root colonisation was also not affected. The presence of yeast reduced the no. of galls per plant.

Effect of VAM and Rhizobium alone or in combination on nematode resistant and susceptible varieties of cowpea that the plant growth parameters were significantly increased in both susceptible (Bundel lobia-1) and resistant (C-152) varieties by the presence of these organisms and the adverse effect of nematode was mitigated to a considerable level (Table 47).

In cowpea extremes of pH, *i.e.,* 5.5 and 9.5 adversely affected the plant growth parameters and also no. of nodules, per cent root colonisation and no. of galls produced. However, at 7.5 pH maximum response of VAM and *Rhizobium* was recorded as compared to other levels.

Table 47 : Effect of VAM (Gf), *Rhizobium* (Rhiz) and *Meloidogyne incognita* (Mi) on susceptible and nematode resistant cowpea

Treatments	Pl. ht. cm.	Fresh wt. g/pot	Dry wt. g/pot	No. of nodules /plant	% Root colonisation	No. of galls/ plant	P content (%)	N content (%)
Susceptible (Bundel lobia-1)								
Control	25.66	25.00	5.76	-	-	-	0.1001	2.24
Gf.	33.33	39.66	8.10	-	50.66	-	0.1543	2.35
Rhiz.	34.00	41.33	8.30	67.66	-	-	0.1306	2.64
Mi.	22.00	21.33	5.40	-	-	82.00	0.0893	2.15
Gf + Rhiz.	37.66	51.33	10.30	74.66	58.33	-	0.1836	2.71
Gf + Mi.	21.33	28.33	5.70	-	38.33	60.33	0.1456	2.29
Rhiz. + Mi.	23.33	32.66	6.60	47.33	-	74.33	0.1276	2.45
Gf + Rhiz. + Mi.	27.00	44.33	9.53	53.33	51.66	53.00	0.1303	2.55
Resistant (C-152)								
Control	26.66	25.00	5.13	-	-	-	0.1053	2.27
Gf.	36.00	38.66	8.10	-	54.00	-	0.1603	2.39
Rhiz.	38.33	41.66	8.53	69.66	-	-	0.1360	2.66
Mi.	24.66	26.00	5.46	-	-	11	0.0920	2.26
Gf + Rhiz.	37.00	53.33	10.56	75.00	59.00	-	0.1910	2.76
Gf + Mi.	31.00	36.00	7.76	-	52.66	6.66	0.1546	2.33
Rhiz. + Mi.	33.00	38.66	8.23	68.33	-	6.66	0.1286	2.49
Gf + Rhiz. + Mi.	37.66	48.66	11.46	72.00	57.00	4.00	0.1366	2.58

3.9 REGIONAL RESEARCH CENTRE, DHARWAD

AGRO-SILVIPASTORAL STUDIES

Pennisetum pedicellatum perennial + *Stylosanthes scabra* mixture (24.07 t/ha) out yielded all other combinations. The decreasing order of green fodder production (total of 3 cuts at 60 days interval) are from Deenanath perennial + *S. scabra, Brachiaria* + *S. scabra, Cenchrus* + *S. scabra*, PTH + *S. scabra* and *S. scabra* in pure stands. The mean plant height (cm), number of branches and collar diameter (cm) at 10 cm height were recorded for tree components, the values for *Hardwickia* were 80.9 cm; 3.0 and 2.75 cm and for *Leucaena* are 47.8 cm, 2.2 and 1.29 cm, respectively.

Desmanthus was sown in small (0.3 ha) area for seed production. Work is in progress on its multiplication using stem cuttings with 1-3 buds.

Fodder production on bunds

Eighteen treatmests were replicated thrice on newly formed bunds in small holder farming systems. Each treatment was imposed on 4 m running length of the bund. Among the treatments tried, *Pennisetum* trispecific hybrid on lower ridge and *Cenchrus* on upper ridge recorded highest forage yield (5.0 kg/4m) followed by *Pennisetum* trispecific hybrid + *S. hamata* (4.35 kg), DHN-15 + *S. hamata* (4.20 kg) and IGFRI-3 + *Cenchrus ciliaris* (3.35 kg). Among the grasses and legumes tried on lower ridge of bund *Pennisetum* trispecific hybrid, *Pennisetum* hybrids *viz.,* DHN-15 and IGFRI-3 found suitable in terms of establishment and fodder production. Among the grasses and legumes tried on upper ridge of bund, *Brachiaria decumbens* recorded highest fodder yield, whereas *S. hamata, C. ciliaris* and *B. decumbens* established very well.

Farmers showed interest to grow fodder on bunds and they showed inclination and desire to grow *B. decumbens* and PTH. *B. decumbens* has been harvested 3 times during the season and PTH only once. *B. decumbens* recorded highest green forage yield of 2.2 kg/m running area of bund size 3'x2'x1' at each cutting.

CROP IMPROVEMENT

Fodder Bajra

Among the fodder bajr varieties developed at the station, DRSB-2, which has consistently performed well in all the three years of evaluation in AICRP trials for green, dry fodder and crud protein yield, is proposed for further identification and release. The entries DRSB-3, 4 and 5 are being evaluated in advanced trials of AICRP. In F_2 generation of foddder bajra, superior plants have been selected for further evaluation.

Hybrid Napier

Two of the Bajra X Napier hybrids DHN-1 and DHN-4 are being evaluated under AICRP trials. The hybrid DHN-2 has exhib-

ited superior performance in second year of evaluation also under coconut orchards, at Goa Research Complex, Goa.

Farmers participatory hybrid napier selections were done in station trials of hybrid napier developed at the station. Farmers from three districts *viz.,* Dharwad, Belgaum and Uttara Kannada and who were already growing hybrids such as NB-21, PBN-16, CO-1 etc. participated in the programme. Six trials are under way in the farmers field (three under normal irrigated conditions and three under orchards). The selected hybrids are DHN-11, DHN-2, DHN-4, DHN-5, DHN-9, DHN-10, DHN-11 and DHN-12.

Seed production of Alfalfa

To study the variation of pellenkitt and its influence on seed production of alfalfa, a replicated trial was laid out involving seven cultivars T-9, CO-1, RL-87-1, RL-88, LLC-3, Anand-2 and Anand-3 of lucerne.

AICRP trials

In initial and advanced varietal trials on cowpea none of the entries tested were superior to checks UPC-5286 (25.1 t/ha), and Bundel lobia (24.4 t/ha) for green fodder yield. But in fodder bajra trials, though many entries were superior to checks, UUJ-IV M (20.37 t/ha) and CO-8 (21.1 t/ha), only DRSB entries were either on par or superior in performance to best check FMH-3 for green (24.5 t/ha) and dry fodder yield (13.19 t/ha).

Disease and insect pest management

In a trial involving the following range grasses, occurrence of different diseas under field conditions was monitored.

In *Chloris guyana* out of the 3 cultivars *viz.,* Callide, Katambar and Nemkat, the tetraploid Callide showed leaf spot caused by *Bipoloaris* species. The leaf spot symptoms and stem lesions in other cultivars needs to be identified.

In *Bothriochloa insculpta* cv. Biset, anthracnose caused by *Colletotrichum* was observed. In *B. pestura*, out of the 3 cultivars *viz.,* Keppal, Midway and Dawson, Midway showed symptoms of anthracnose. However, other cultivars showed *Rhizoctonia* lesions in the early stages of establishment.

In *Setaria spachelata* cv. Solander *Cercospora* leaf spot and Pyricularia was observed. In *Dicanthium,* 2 species *viz., aristatum* and *Melangiana* were scored. In *D. aristatum* cv. Floren and in *D. melangiana* cvs. Strickland and CI & 41192 did not show any significant symptoms. Likewise *Panicum coloratum* cv. Bambatsi, *Eurochloa mosambiensis* cv. Saraji were also free from diseases.

In tall fescue cv. Doney and hybrid rye Elonet and Prior, leaf spot caused by *Rhynchopoium* was observed. In hybrid rye Elonet mild to moderate disease severity was observed. In both the grasses clumps drying and death was noticed.

In pasture legumes, 3 cultivars of *Desmanthus virgatus* with varied growth habits i.e., erect, semi-spreading and spreading, no disease was observed. However, cv. Marc was affected with *Heteropsylla*.

In *Clitoria ternatea* cv. Milgassa leaf and pods were found affected with anthracnose caused by *Colletotrichum gloesporoides* and *C. truncatum*.

Out of two lucerne cvs. *viz.,* Trifecta and Sobilt, Trifecta was found highly resistant to rust where as Sobilt was highly susceptible.

In white clover leaf miner damage was severe. The casual organism was *Aproerema modicella* and its pupae was parasitised by *Braconid* insect.

Stylosanthes scabra differential cultivars *viz.,* Fitzroy, Seca, 36260, Q10042 and Viscosa; *S. guianensis* cvs. Cook, Endeavour and Oxley; *S. hamata* 5 cultivars and one hybrid were montiroed during June to September for field reaction against anthracnose pathogen *Colletotrichum gloesporoides*. Necrotic leaf area was calculated for each accession at random following leaf disease rating scale (CSIRO, Australia). Fitzroy was found to be highly susceptible under field conditions followed by 36260. Seca was found resistant. In *S. guianensis* field reaction to type B pathogen showed that Cook as highly susceptible. In *S. hamata* the disease reaction was observed similar in all accessions except that Verano and 75164 showed stem lesions in addition to leaf necrosis. In all the cases disease severity was more during August and September.

All instars of *Helicoverpa* larvae was noticed at the rate of 5-13/ plant and 2-8/ plant on *scabra* and *guianensis* cv. Cook respectively. This is the first time larvae have been noticed on *guianensis*.

3.10 REGIONAL RESEARCH CENTRE, PALAMPUR

The regional research station at Palampur was established in December 1996.

CROP IMPROVEMENT

Eight collection of white clover were made from Palampur and four from Bajoura and Gharsa, besides four exotic collections from UK.

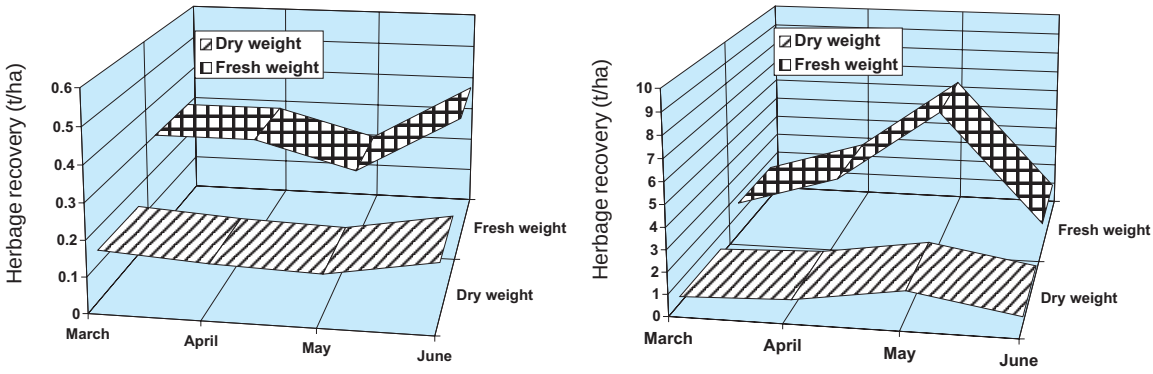
All the collection showed maximum growth from May to August. The collections made from these areas continued to be more vigorous.

The percentage seed germination of exotic lines, seeds collected from different collections of white clover and some other species of *Trifolium* was determined under laboratory conditions.

GRASSLAND MANAGEMENT

The production of grass dominated and legume dominated grasslands was estimated in natural grasslands of Palampur.

The differential growth pattern during premonsoon period offers a production of leguminous herbage. The green herbage yield of 6.22 t/ha can further be enhanced by various management interventions (Fig. 24).



Grass dominated pasture **Legume dominated pasture**

Fig. 24 : Herabge recovery pattern in legume and grass dominated pastures

4. TECHNOLOGY ASSESSED AND TRANSFERRED

FARMERS' DEMONSTRATION BLOCK

On farm field demonstrations on proven fodder production technologies were conducted at Farmers' Demonstration Block. The various fodder production systems such as three-tier system, silvopasture system, agroforestry system, hybrid napier based round the year fodder production system, Setaria/Guinea based round the year fodder production system and fodder annual crops based production system produced highest forage yield ranging 180.0 to 250 t/ha followed by hybrid napier based round the year fodder production system (102.0 to 150 t/ha)

DEMONSTRATION AT FARMERS' FIELD

During *kharif*, 47 forage field demonstrations were laid out on improved varieties of sorghum, M.P. Chari, guar and cowpea. The average yield of jowar + cowpea and M.P. Chari + guar ranged from 42.0 to 45.0 t/ha, while in local practice yield was around 22.0 t/ha.

During *rabi,* 75 forage field demonstrations on improved varieties of berseem and oats were laid out. The average yield 65.0 t/ha of berseem (var. Wardan) and 47.0 t/ha of oat (var. JHO-822 and 851) was obtained, while in local practice yield of berseem was around 21.0 t/ha.

KISAN GOSTHI AND MAHILA DIWAS

A large number of farmers, farm women, extension workers, developmental officials from various departments such as Soil Conservation, Forest, Animal Husbandry and Agriculture participated in the Kisan Gosthi, Mahila Diwas and Exhibitions, etc.

PARTICIPATION IN EXHIBITION/ GOSTHI

The Exhibition stall at CIRG, Makdoom, Mathura was held on 9.1.1998. A large number of visitors including Dr. R.S. Paroda, Director General & Dr. M.L. Madan, DDG

Activities	No.	Venue	Date
Kisan Gosthi	1	Gursarai (Jhansi distt.)	1.10.1997
Mahila Diwas	1	Shervas Kalan Talbehat block (lalitpur distt.)	18.10.1997

Note : The mini-kit seed of improved variety of berseem and oats were distributed to farmers for demonstration of these dates.

(A.S.), important senior officers from ICAR headquarters, New Delhi and other places. The IGFRI technologies were explained to the visitors and relevant extension literature on forages were distributed.

Participated at *Rabi* Fasal Gosthi organised by IFFCO, Jhansi at Kalyanpura village, Lalitpur district on 3.12.1997.

VISITS

A large number of visitors/ progressive farmers, batches of Forest Guards, B.Sc. Forestry Students, KRIBHCO farmers, dairy farmers, progressive fodder growers, commercial dairy entrepreneurs, Forest and Soil Conservation officials visited the Institute and latest forage technologies have been explained to them from time to time.

RADIO/T.V. TALK

Number of Radio/TV talks were delivered by the Institute Scientists.

FARM POSTAL SERVICE

Large number of postal enquiries were received from various parts of the country. The advisory services have been provided to the users/clients.

FARMERS' SERVICE CENTRE

The Farmers' Service Centre for the sale of seeds of improved varieties of forage crops and other planting materials of grasses was inaugurated by Dr. Mangla Rai, Deputy Director General (Crop Science), ICAR on 20.12.1997 for the benefit of farmers and other users. The centre attends the work of Advisory Service to the farmers on matters related to forage production.

5. TRAINING

The Institute is having a comprehensive training programme on all possible facets of grassland and fodder production and its efficient utilization. The training programme of the Institute are categorised as:

(i) International Training Programmes

(ii) Nine-month Diploma Course on Forage Production and its Utilization

(iii) Short-term Refresher course extending from one week to three months in the specific field of grassland and fodder production and its utilization

(iv) Peripheral training for develpmental workers and farmers.

The FAO sponsored International Training on "Management and Utilization of Fodder Trees/Shrubs in Sub-tropical and Termperate Himalaya" was organised at this Institute, during September 22-30, 1997. Ten participants, two from Nepal, one from Bhutan and seven from India attended this training course.

Besides Nine -Month Diploma Course, the following training programmes were organised during this year:

Sl. No.	Title of training and sponsoring agency	Date	No. of participants
1.	Training on 'Year round fodder production technology' sponsored by Directorate of Extension, Min. of Agriculture, Govt. of India	Sept. 5-12, 1997	18
2.	'Van Jankar Training Programme' sponsored by KRIBHCO-Indo-British Rainfed Farming Project, Dahod, Gujarat	Nov. 10-12, 1997	23
3.	'Van Jankar Training Programme' sponsored by KRIBHCO-Indo-British Rainfed Farming Project, Dahod, Gujarat	Nov. 10-12, 1997	30
4.	'Van Jankar Training Programme' sponsored by KRIBHCO-Indo-	Nov. 13-15, 1997	29

Sl No.	Title of training and Sponsoring agency	Date	No. of participants
	British Rainfed Farming Project, Dahod, Gujarat		
5.	'Van Jankar Training Programme' sponsored by KRIBHCO-Indo-British Rainfed Farming Project, Dahod, Gujarat	Nov. 17-19, 1997	31
6.	Training Programme, 'Fodder and Pasture Development in Forestry Management', sponsored by A.P. Forestry Project, Govt. of Andhra Pradesh	Nov. 24-30, 1997	22
7.	Improved Fodder Seed Production Techniques for Cultivated Forages, Grasses and Legumes, sponsored by Technology Mission on Dairy Development, Government of India	February 23-28,1998	24
8.	Training Programme on Animal Feed, Fodder and Pasture Development	March 2-29, 1998	8

6. AWARDS AND RECOGNITIONS

In recognition to his exemplary performance, the name of Dr. Bhag Mal, Director has been recomended to the Governing Board of Editors of American Biographical Institute. He has also been nominated as member :

- Central Sub-committee for release and notification of crop varieties, Ministry of Agriculture, Govt. of India.
- Uttar Pradesh State Varietal Release Committee, Lucknow.

Dr.C.R.Hazara, Project Coordinator, AICRP (FC) has received Soil Conservation Society of India-Leadership Award,1996 in recognition to his significant contribution in the field of Integrated Watershed Development, Forage Crop Improvement and Agroforestry Development.

7. LINKAGES AND COLLABORATION IN INDIA AND ABROAD INCLUDING EXTERNALLY FUNDED PROJECTS

INDO-UK COLLABORATIVE PROJECT

IGFRI has an effective international collaboration. An Indo-UK Collaborative project on Forage Production is currently operating at the Institute. The first phase of the project has been completed successfully. The second phase of the programme with emphasis on forage utilization and livestock production has already been worked out.

The final recommendation of MTR Mission has expressed great satisfaction for the good progress made under this project during the past three years. The mission has recommended DFID, UK for additional amount of 0.28 million for remaining period of two years. The key aspects of additional schemes are focused PRA, Seed Production Technology including provision for revolving fund, farm based adaptive research, strengthening of three IGFRI Regional Research Stations and Human Resource Development, etc.

A workshop on client orientation was organised at the Institute during Nov. 17-22, 1997. The underlying objective of this workshop was to identify whether technologies existed "on-the-shelf; that had potential for rapid uptake and impact, and if so, how they might most effectively and rapidly be disseminated. It was further, aimed at stimulating discussion and reflection among scientists on how research problems and clients for research should be identified and the other characteristics that research must have if technologies driving from it are to have good prospects of uptake and impact.

A workshop was organised at the Institute from March 2-4, 1998 to look into the potential and constraints of 'On farm research' to be undertaken by IGFRI. The participants of the workshop discussed the implications of farmers as experimenters (Indigenous knowledge), planning on farm experiments, designing on farm trials, trial management decisions, and implementing experiments. The participants identified some key areas where 'on farm research' may be carried out, but main emphasis was on the ongoing 'on farm trials', namely, forage on bund and stay green sorghum trials.

A workshop on participatory Plant Breeding was held between March 5-11, 1998. Plant Breeders, Geneticists and Agricultural Economists of the Institute attended the deliberations. This was followed by on field studies in high production potential areas in Godhra (Gujarat).

The workshop gave an insight into the role of Participatory Varietal Selection (PVS) and Participatory Plant Breeding (PPB) for better dissemination of technology and adoption by the clientele. Case studies revealed that the adoption by farmers is better through PVS & PPB than by top down dissemination of technology.

FAO COLLABORATION

The FAO sponsored International Training on "Management and Utilization of Fodder Trees/Shrubs in Sub-tropical and Temperate Himalaya" was organised at this Institute, during Sept. 22-30, 1997. Ten participants, two from Nepal, one from Bhutan and seven from India attended this training course. The course was inaugurated by Dr. Mangala Rai, Deputy Director-General (Crop Sciences), ICAR, New Delhi on Sept. 22, 1997. The FAO, Rome was represented by Dr. John Morrision. Dr. Mangala Rai in his inaugural address emphasized on greater R&D efforts in this important resource area.

ICRA COLLABORATION

Dr. JRV Daane, Director, International Centre for development oriented Research in Agricultural (ICRA), Wageningen, The Netherlands visited IGFRI during November 20-27, 1997. The purpose of his visit was to explore the possibility of collaboration between ICRA and ICAR Institute. During his stay at IGFRI, he participated in the Client Orientation Workshop and inaugurated a training programme of forest officials of Andhra Pradesh. Two IGFRI scientists were selected for 1998 ICRA Programme. It was also agreed to have ICRA field study at this Institute during the forthcoming training.

8. AICRP / COORDINATED UNIT / NATIONAL CENTRES

ALL INDIA COORDINATED PROJECT FOR RESEARCH IN FORAGE CROPS

Varietal development

Strains which showed promise under All India Coordinated trials are given in table 48. The varieties identified for release notified and released are given as under :

Varieties released and notified

Berseem : Bundel Berseem -2 variety is suitable for Central and North West Zone of the Country. It has significant improvement for dry matter content and resistance to major diseases and pests.

Oats : The variety JHO-851 is a multicut, uniform in growth habit and suitable for all Oat growing tracts. This is fairly resistant to major diseases and pests.

Bajra : FMH-3 is a first multicut hybrid of fodder bajra. It has shown consistent superiority for green and dry matter yields for almost all the locations individually and on the basis of mean over the locations. The hybrid has added advantage of resistance to major disease and pest especially downy mildew. This is identified for release for entire fodder bajra growing areas of the country by Central Sub-Committee on Crop Standards, Notification and Release of Varieties both as single and multi-cut material.

Identified for Release

Guar : The strain IGFRI-1019-1 has shown superiority of 15% for green fodder and 12% for dry matter yield over the check, HFG-119.

Cowpea : Strain UPC-9202 has shown superiority for GFY and DMY in Central zone of the country. The strain has added advantage for quality parameters as well.

Maize : The strain APFM-8 has shown superior performance in North-East and North-West Zone both for green and dry matter yield. It has added advantage of being yellow seeded type and early maturity by 10 days.

Berseem : The strain JHB-89-4 has shown better performance for its forage yield, quality parameters and disease resistance as compared to check in Hill zone. It has shown significant response to phosphorus application as well.

Plant Protection Research

In berseem root rot disease (*Rhizoctonia solani, Fusarium semitactum*) damage was high at Jhansi, Kanpur, Jabalpur and Faizabad. The stem rot disease (*Sclerotinia trifoliorum*) was more prevalent at Jhansi and Kanpur. The heavy incidence of hairy caterpillar were observed at Faizabad. In oats, incidence of leaf blight (*Helminthosporium avenae*) was visible at Jabalpur, Jhansi, Faizabad, Kanpur and Pantnagar. The sclerotial wilt (*Sclerotium rolfsii*) was limited to Jhansi centre only. In lucerne downy mildew (*Peronospora trifolii*)

Table 48 : Promising strains for forage production

Crop	Variety	Suitable area for cultivation
Berseem	JHB-96-5	Central and North West Zone
	JHB-96-4	- do -
	BL-153	North West and South Zone
	HFB-60	North West Zone
Lucerne	Anand-6	All India
	RL-87-2	All India
Oats (Single cut)	JHO-96-1	North East Zone
	UPO-254	- do -
	OL-969	- do -
	PLP-12	- do -
Oats (Multicut)	UPO-253	All India
	OL-1062	All India
Cowpea	UPC-604	North West Zone
	UPC-605	- do -
	IFC-9701	Central Zone
Guinea grass	JHGG-96-4	All India
	JHGG-96-5	- do -
Bajra x Napier Hybrid	BN-9203	All India
	APBN-1	- do -
	Co-1	- do -
	Co-3	- do -
Pearl millet (Single cut)	FMH-1	Entire Bajra growing tract
	DRSB-3	- do -
	DRSB-4	- do -
	DRSB-5	- do -
Pearl millet (multicut summer)	FMH-4	Entire Bajra growing tract
	UUJ-1	- do -
	UUJ-2	- do -

and rust (*Uromyces striatus*) was prevalent at Hyderabad and Jhansi centres. The lucerne weevil (*Hypera postica*) incidence was high at Jhansi. Results under artificial epiphytotics at Jhansi indicated BL-131 and BL-142 of berseem to be resistant to stem rot. Oat entries UPO-253 and JHO96-5 were found to be resistant to leaf blight. The entries showing less degree of susceptibility to sclerotial wilt were Kent, UPO-212, JHO-96-4, JHO96-6 and PLP-11.

Production Technology

- Application of 20 to 40 kg S per hectare through soil in combination with full recommended dose of NPK increased the forage yield of oat to the extent of 20 percent. 20 kg S/ha was found beneficial in berseem for increased forage yield. Application of 60 kg S/ha significantly increased seed yield of Shaftal by 25% over control.
- In fodder oats, manual weeding at 4 weeks crop stage coupled with post emergence application of 2-4-D @ 0.37 kg a.i./ha at 6 week crop stage was found economically viable to control weeds and increase in fodder yield.
- The use of vermicompost as organic source of nutrient increased green fodder yield of oats by 5 to 12% over full inorganic fertilisation.
- Early sowing followed by subsequent cuttings (2-3) in oats, and 0.5% foliar spray of thiourea after each cut increased forage yield. Foliar spray of thiourea @ 0.1% at flowering stage increased the seed yield of oats. Highest seed yield of berseem was realised when sown with a seed rate of 7.5 kg/ha and 45 cm apart; while, higher seed yield of lucerne was obtained at 30 cm spacing and a seed rate of 5 kg/ha .
- Oat cv. UPO-240 recorded highest forage yield, when the crop was sown with 100 kg seed/ha and fertilised @ 120 kg N/ha.
- Under coconut garden, guinea grass yielded more green fodder per unit area than gamba grass.
- The continuous use of organic manures in combination with 75% inorganic fertilizer gave 11 to 15% higher monetary return per hectare than sole application of inorganic fertilizer.

NETWORK COLLABORATIVE PROGRAMME ON CROP BASED ANIMALS PRODUCTION SYSTEM

There are 4 grazing systems (4 plots of 4.0 ha each), such as (i) Rotational (ii) Deferred rotational (iii) Continuous (iv) Cut and Carry. Deferred rotational system gave higher forage yield in most of the cases. Vegetation studies such as relative density and relative frequency were recorded in all the systems. *Cenchrus ciliaris* is the dominant among the grasses and *Indigofera cordifolia* is the dominant among legumes. Plant vigour study of *Cenchrus ciliaris* and *Indigofera cordifolia* were also done.

Pasture improvement studies

Total dry forage production ranged from 3.5 and 8.6 t/ha in village grassland and continuous grazing system respectively. In

comparison to previous year the total forage production decreased in rotational (32.1 per cent) deferred rotational (19.1 per cent) and continuous (5.4 per cent) while in cut & carry system 12.6 per cent increase was recorded. In village grassland the forage production remained at par.

Forage Evaluation and Livestock Production

Under three different systems of grazing : rotational, deferred-rotational and continuous, four crossbred cows, nine ewes (corriedate x local) and nine Barbari does were introduced for grazing in each system, while under cut & carry system a group of similar number animals were stall fed.

Dry matter and CP content of mouth grab samples from goats were 34.35 and 11.34, 34.02 and 12.67, 32.71 and 10.21, 41.81 and 5.52 per cent in rotational, deferred-rotational, continuous and cut & carry systems respectively during the month of Oct.,1997. The intake of DM (percent of body weight) in goats under stall feeding condition was 3.57 and DM digestibility was found to be 52.82%.

Body weight of cattle increased in rotational, deferred-rotational and continuous systems of grazing up to the month of November except in cut & carry group where it was just maintained. The sheep and goat (average live weight 28.11 and 21.53 kg), respectively apparently maintained their weight with slight gain under rotational, deferred-rotational and continuous system of grazing management while under cut & carry system both the species lost the weight amounting to 22.38% in sheep and 12.55% in goat up to December .

Average yield of wool per sheep was 516, 618, 577 and 409 g in rotational, deferred-rotational, continuous and cut & carry systems, respectively during the month of May, 1997 while the corresponding values for the month of October were 720, 843, 839 and 716 g.

Total milk yield in cattle from Ist July,97 to 31st Dec, 97 was 2936.5 kg (4 animals) in rotational, 2050 kg(4 animals) in deferred-rotational and 2118.5 kg (2 animals) in continuous grazing systems. No calving was observed under cut & carry system.

Economics of crop based animal production system

The economics of fodder and livestock production system for 1996-97 have been presented in Table 49, which reveals that cut & carry system is the most labour-intensive system followed by the Deferred-rotational system. Highest value of fodder production obtained under the deferred-rotational system followed by the continuous system. Highest cost of livestock rearing is incurred under Deferred-rotational system. Highest value of livestock production is obtained from deferred-rotational system followed by rotational, continuous and cut & carry system. Highest cost of crop based production system (fodder production and livestock rearing components merged) was involved in cut & carry system followed by deferred-rotational, continuous and rotational systems. Deferred-rotational system proved most profitable followed by rotational, continuous and cut & carry systems.

Table 49 : Economics of crop based livestock production system under different grazing management systems

(in Rs./ha/1.5 Acu)

	Rotational system	Deferred rotational	Continuous system	Cut and Carry system
Value of fodder production (Rs.ha.)	17365.00	18135.00	17883.50	15266.50
Livestock production value	9392.96	12747.20	7017.61	3923.26
Net Return per hectare	11319.55	13450.92	9437.27	848.30

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Baig, M.J., R.K Bhatt, Anjali Chatrath and P.K. Mandal. प्रकाश की विभिन्न तीव्रताओं के अन्तर्गत घासों एवम् दलहनी की प्रकाश संश्लेषण क्षमता तथा चारा उत्पादकता. pp. 27.

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Faruqui, S.A. and K.C.Pandey. चारा फसलों में नाशी कीट प्रबंधन. pp. 33.

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Gupta, S.D. and J.V.N.S. Prasad. चारे की फसलों में खरपतवार नियंत्राण. pp. 23.

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Malaviya,D.R., A.K.Roy and P. Kaushal. बरसीम मे आनुवांशिक सुधार समस्याएँ एवं समाधान के उपाय. pp. 42.

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Misri, B. शीतोष्ण क्षेत्राों में चरागाह का विकास. pp. 49

Nag, S.K., B.K.Bhadoria, A.S.Negi and R.S.Upadhyaya. तलहटी झाड़ियों का चारे की सम्भावना हेतु मूल्यांकन. pp. 78.

Negi, A.S., S.K.Nag and B.K.Bhadoria. दलहनी चारा वृक्षों में पोषक बाधक तत्व. pp. 97.

Niranjan, K.P., R.L. Arya and A. Singh. शुष्क क्षेत्राों में अन्न–चारा उत्पादन पद्धति. pp. 22.

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Padmavathi, Ch., A.A. Khan, S.N. Singh, Rakesh Seth, Dinesh Kumar Bishnoi and Naveen Chander. चारा फसलों के बीजों का भण्डारण एवं कीट–ब्याधि नियंत्राण. pp. 107.

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Patra, A.K., M.R. Pahwa and A. Singh. बुन्देलखण्ड क्षेत्रा की लाल बंजर मृदाओं की उत्पादकता सुधारने के लिए स्टाइलो सैन्थिस हमाटा pp. 83.

Pradeep Behari, J.B. Singh and S.K. Rai. चारा उत्पादन में वाष्पोत्सर्जन का प्रभाव. pp. 20.

Rai, S.K. and Pradeep Behari. मध्यम अवधि के मौसम पुर्वानुमान की कृषि में उपयोगिता. pp. 82.

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Rawat, C.R. and C.R. Hazra. बारानी क्षेत्रों में चारा उत्पादन – अनुसंधान एवम् विकास . pp. 6.

Roy, A.K., D.R. Malaviya and P. Kaushal. ऊतक संवर्धन तकनीकी द्वारा बरसीम की अनुवांशिक गुणवत्ताओं में सुधार. pp. 41.

Roy, M.M., M.P. Rai and B.K. Choubey. बुन्देलखंड क्षेत्रा की अनुपजाऊ भूमि पर चयनित वन चरागाह पद्धतियों की उत्पादकता – एक अध्ययन. pp. 74.

Sai Prasad, S.V., D.S. Katiyar and U.S.Mishra. चारा ज्वार की उत्पादकता में अंशभूत, परम्परा से प्राप्त वंशानुगत विभिन्नता एवं अर्न्तसम्बंधों का योगदान. pp. 36.

Samanta, A. K., Tej Kumar Walli, K. K. Singh and G. H. Pailan. अवायुजीवी फफूंद का भैसों की पाचन क्रिया में योगदान. pp. 90.

Saxena, P., P.K. Katiyar and D.K. Agarwal. सिराट्रो एवं स्टाइलो के पितृद्रव्यों का पर्णीय अंगमारी तथा कालव्रणा रोगों के प्रति प्रतिरोधिकता का आंकिक विश्लेषण. pp. 38.

Seth, R., Ch. Padmavathi, D. Kumar and A.A. Khan. चारा फसलों में बीज उत्पादन, प्रमाणीकरण, वितरण व्यवस्था तथा गुणवत्ता नियंत्राण : एक अवलोकन. pp. 107.

Shah,N.K.सेहिमा – हेटरोपोगोन प्रभावी चरागाह की कीट समस्या एवं उसका समाधान. pp. 60.

Sharma, K.C., R.K. Agrawal and P.S. Tomer. फसल चक्रों का उन्नतिशील तथा कृषिकों के संसाधन स्तरों पर तुलनात्मक अध्ययन. pp 43.

Shukla, G.P. and C.R. Hazra. चारा बीजोत्पादन में वृद्धि – शोध एवं सुझाव. pp. 104

Shukla, N.P. and Shiva Dhar. चारा फसलों के जल प्रबन्धन. pp. 26

Singh, A., A.S. Gill, R.L. Arya and R.V. Singh. बुन्देलखण्ड के बरानी क्षेत्राो में खेती सम्बन्धी समस्याऐं एवं उनका समाधान. pp. 45.

Singh, A., R.L. Arya, K.P. Niranjan and J.B. Singh. संसाधन संरक्षण द्वारा बारानी परिस्थितियों में नमी संरक्षण. pp. 82.

Singh, Atar. चारा उत्पादन तकनीकी प्रसार में महिलाओं की भूमिका. pp. 110

Singh, D. N.`सेम में उन्नत चारा प्रजातियों का विकास. pp. 35.

Singh, J. and P.D. Gupta, चारा कटनोत्तर प्रोद्योगिकी का विकास. pp. 89.

Singh, J.B. and C.R. Hazra 1997. झाँसी की वर्षामान विशिष्टताओं में दशकीय परिवर्तन और बारानी दशाओं में चारा फसल नियोजन. pp. 43

Singh, J.P. राप्ती अपवाह क्षेत्रा में पशुधन समायोजन, चराई पद्धति एवं चारा उपलब्धता–एक भौगौलिक अध्ययन . pp. 51.

Singh, K. K., Bandla Srinivas evam A. K. Samanta. चारा फसलों की परिपक्व अवस्था का मुख्य लवणों की रुमेन में घुलनशीलता तथा उपलब्धता पर प्रभाव. pp. 96.

Singh, K.,C.R. Rawat, C.R. Hazra and Sunil Kumar. जई में समेकित पोषक तत्व प्रबन्ध : एक सांख्यिकीय अध्ययन. pp. 28.

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10. LIST OF APPROVED ON-GOING PROJECTS

CROP IMPROVEMENT

CI 1: Collection, evaluation and maintenance of genetic resources of forage crops

1.1 Collection, evaluation and maintenance of genetic resources of forage grasses

(A.K. Roy, D.K. Agarwal, Sanjeev Gupta, N.K. Shah and R.B. Bhaskar)

1.2 Collection evaluation and maintenance of genetic resources of forage legumes

(U.P. Singh,O.P.Dixit,D.K. Agarwal,P.K. Katiyar, P. Saxena, S.A. Faruqui and A.S.Negi)

1.3 Conservation of forage plants and genetic resources

(O.P.Dixit,U.P.Singh and D.K.Agarwal)

CI 2: Production and quality breeding in cereal fodders

2.1 Breeding superior varieties of forage sorghum (*Sorghum bicolor*)

(D.S. Katiyar, U.S. Mishra, S.V. Sai Prasad, S.A. Faruqui,R.B.Bhaskar, M.J. Baig and Sultan Singh)

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

(R.N.Choubey, S.N. Zadoo,A.K.Roy, S.V. Sai Prasad,A.Chatrath and P.N.Dwivedi)

2.3 Improvement of Fodder Maize (*Zea mays*)

(R.N.Choubey, B.S. Chaudhary, P.K. Katiyar, P. Saxena, M.I.Azmi, M.J. Baig , N.K. Shah and Anil Kumar)

CI 3 : Breeding superior varieties of cultivated fodder legumes

3.1 Breeding varieties for high fodder yield and quality in cowpea (*Vigna unguiculata*)

(K.S. Kohli, C.B. Singh, D.K. Agarwal,Sharmila Roy, R.B. Bhaskar, N.C. Verma and N.Hasan)

3.2 Improvement of Lucerne (*Medicago sativa*) for yield and persistance

(C.B. Singh, K.S. Kohli, P.K. Katiyar, K.C. Pandey, M.I.Azmi, A.Chatrath, S.N.Tripathi, P. Saxena and B.K. Bhadoria)

3.3 Genetic Improvement of berseem *Trifolium alexandrum*

(D.R. Malaviya, A.K.Roy, P. Kaushal, Amresh Chandra, N. Hasan, K.C. Pandey, R.B. Bhaskar and S.K. Mahanta)

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

(D.N. Singh , S.N. Tripathi, R.B. Bhaskar, N.K. Shah and L.K.Karnani)

CI 4 : Breeding superior varieties of pasture species for yield and persistance

4.1 Varietal improvement for yield and quality in range grasses

(U.S. Mishra, D.S. Katiyar,Vishnu Bhat, N.K.Shah, P. Saxena and L.K. Karnani)

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

(P. Kaushal,D.R. Malaviya and K.K.Singh)

CI 5 : Cytogenetic studies in forage and pasture species

5.1 Cytogenetical studies in cultivated legumes.

(S.N. Tripathi , D.N. Singh and A.B.Mazumdar)

5.2 Interspecific hybridiazation in *Pennisetum*

sp. for production of perennial apomictic lines

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

CI 6 : Genetic improvement of forage species through biotechnological methods

6.1 Genetic manipulation for the improvement of grass species and their molecular characterisation

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

6.2 *In vitro* genetic manipulation for the Improvement of forage legumes

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

6.3 Micro-propagation of elite genotypes of multipurpose trees

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

CI 7: Physiological and biochemical studies in forage crop improvement

7.1 Morpho-physiological studies of C_3 and C_4 grasses and legumes under light stress

(M.J. Baig ,R.K. Bhatt, A.Chatrath and P.K.Mandal)

7.2 Biochemical mechanism/response of disease resistance in cowpea (*Vigna unguiculata*) and stylo

(Amresh Chandra, A.Chatrath, P.K.Mandal and P.Saxena)

7.3 Physiological and biochemical basis of tolerance to secondary salinisation in lucerne*(Medicago sativa*)

(Anjali Chatrath, M. Anuradha , Pranab Kumar Mandal and M.J.Baig)

7.4 Seed ageing and its alleviation in forage crops.

(O.P.S. Verma, M. Anuradha and O.P.Dixit)

7.5 Foliar nutrition for increasing fodder and seed production in lucerne(*Medicago sativa*)

(M. Anuradha, Anjali Chatrath and M.J.Baig)

7.6 Isozymes and RAPD analysis for disease and pest resistance in lucerne (*Medicago sativa*)

(P.K.Mandal,A.Chandra,C.B.Singh, K.C.Pandey and P.Saxena)

CI 8 : Studies on diseases, insect pests and nematodes and their management for increased forage production

8.1 Disease of forages and their management

(R.B. Bhaskar , P.Saxena and M.S.Saharan)

8.2 Nematode - fungi disease complexes and their management

(N. Hasan and R. B. Bhaskar)

8.3 Predacious nematodes with reference to predator-prey relationship in forage crops

(M.I.Azmi and N. Hasan)

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

(Sharmila Roy and S.A. Faruqui)

8.5 Insects associated with *Sehima-Heteropogon* dominated grasslands and their management

(N.K. Shah and K.C. Pandey)

8.6 Pesticide residue analysis in forage crops

(S.K.Nag and N.K.Shah)

CI 9: Integrated pest management in intensive forage production

9.1 Integrated pest management for intensive forage production in sorghum + cowpea - berseem + Japan sarson - maize + cowpea system

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

CROP PRODUCTION

CP 1 : Forage production systems under irrigated conditions

1.1 Cropping sequences and varietal evaluation under irrigated conditions

1.1.1 Effect of long term use of organic and inorganic sources of nutrients and crop sequences on soil fertility and crop productivity

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

1.1.2 Performance of sorghum (*S.bicolor*) varieties under different sowing dates and nitrogen levels

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

1.1.3 Effect of nitrogen and phosphorus management on productivity potential and nutritional traits of perennial grass based cropping systems

(R.K. Agrawal,K.C.Sharma and K.K.Singh)

1.2 Nutrient management under irrigated conditions

1.2.1 Studies on Zn and P nutrition in cowpea (*V.unguiculata*) fodder and their residual effect on oats

(O.P.S. Panwar,S.K. Das and Banwari Lal)

1.2.2 Studies on Zn and P nutrition in lucerne (*Medicago sativa*) fodder and their residual effect on forage bajra (*Pennisetum americanum*)

(O.P.S. Panwar, S.K. Das and Banwari Lal)

1.2.3 Studies on Zn and P nutrition in cowpea (*V.unguiculata*) fodder and their residual effect on fodder oat (*A.sativa*) (O.P.S. Panwar, S.K. Das and Banwari Lal)

1.2.4 Soil S test crop response studies under intercropping production system

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

1.3 Integrated nutrient management in forage crops under irrigated conditions

1.3.1 Integrated nutrient management in fodder sorghum (*Sorghum bicolor*) and its residual effect on fodder oats (*Avena Sativa)*

(K.C. Sharma, R.K. Agrawal and A.K. Patra)

1.3.2 Effect of Chemical Fertilizers and Bacterial Inoculations on the Productivity and Quality of Sorghum-Berseem Cropping Sequences

(K.C. Sharma and R.K. Agrawal)

1.4 Water management systems

1.4.1 Irrigation management for perennial lucerne (*Midecago sativa*) in relation to cutting schedules and potassium levels

(N.P. Shukla , Shiva Dhar and D. Burman)

1.4.2 Effect of moisture regimes on productivity of sorghum-berseem and forage bushes under sole and alley cropping systems

(N.P. Shukla, Shiva Dhar, S. Bandyopadhyay and P.N Dwivedi)

1.5 Weed management systems in forage crops under irrigated conditions

1.5.1 Interaction studies between herbicides and some important soil enzyme activities in relation to forage crops

(S.K. Das, R.B. Yadava and M.R. Pahwa)

CP 2 : Forage production systems under rainfed conditions

2.1 Cropping sequences and varietal evaluation under rainfed conditions

2.1.2 Soil moisture and nutrients dynamics of fodder based dry land cropping systems

(R.L. Arya , A. Singh , J.B. Singh and S. Bandyopadhyay)

2.1.3 Effect of different moisture conservation practices on forage and food crops grown under rainfed conditions

(A. Singh, R.L. Arya,N.P.Shukla and D.

Burman)

2.1.4 Effect of different levels of nitrogen and phosphorus on the productivity of *Pennisetum trispecific* hybrid and stylo grown pure and mixed under rainfed condtion

(K.P. Niranjan, R.L. Arya and D. Burman)

2.2 Nutrient management under rainfed conditions

2.2.1 BNF studies in relation to *S. hamata* based mixtures

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

2.2.2 Nutrient dynamics in soil under grass-legume pastures

(A.K. Patra , M.R. Pahwa and Atar Singh)

2.3 Agroclimatological approaches for optimizing forage production

2.3.1 Agroclimatology of Bundelkhand region in relation to forage crop planning

(J.B. Singh and P.S. Tomer)

2.3.2 Evapotranspiration studies in forage crops through lysimetery

(Pradeep Behari , J.B. Singh and A.K. Patra)

2.3.3 Studies of dynamic growth simulation models in fodder sorghum (*Sorgum bicolor*) crop

(Suchit K. Rai, Pradeep Behari and R.K. Bhatt)

2.4 Weed management in forage crops under rainfed conditions

2.4.1 Effective bush killer and its methods of application

(K. Sankaranarayanan and S.D. Gupta)

CP 3 : Forage production on problem soils

3.1 Forage production under saline-sodic soils

3.1.1 Performance of grasses under different sources of amendments grown on saline-sodic soils

(Banwari Lal, J.V.N.S. Prasad and O.P.S. Panwar)

3.1.2 Effect of variable doses of gypsum on performance of winter forages grown on saline-sodic soils

(Banwari Lal, J.V.N.S. Prasad and O.P.S. Panwar)

3.2 Forage production on wetlands

3.2.1 Performance of different forage crops in relation to cutting management under seasonal water logged conditions

(R.L. Arya, S.D. Gupta and V.C. Pachauri)

CP 4 : Technology impact assessment

4.1 Impact of NWDB Project on the land use, cropping pattern and fertility status in Ambabai Village

(R.K. Tyagi and S.K. Das)

GRASSLAND AND SILVOPASTURE MANAGEMENT

GSM 1: Sustainable sustainable Silvopastoral Systems for Rangelands/ wastelands

1.1 Bio-physical spreadsheet modelling of silvopastoral systems

(T. A. Khan, G. Suresh and R. K. Bhatt)

1.2 Optimizing land productivity through silvipastoral system of production

(M. M. Roy and M. P. Rai)

1.3 Root studies of fodder trees in silvopastoral systems

(G. Suresh and T. A. Khan)

CFP: Productivity and patterns of nutrients turnover in selected silvopastoral systems in semi-arid central india

(M. M. Roy)

GSM 2: Sustainable hortipastoral systems

for drylands/ rangelands/ wastelands

2.1 Growth and productivity of fruit crops in association with grasses and legumes

(S.K. Sharma)

2.2 Productivity of Kinnow based Sehima dominated hortipastoral systems

(S.K. Sharma)

2.3 Development of Aonla based *Emblica officinalis* hortipastoral system

(Sudhir Kumar and R.C. Singh)

2.4 Evaluation of Annona based hortipastoral system

(Sunil Kumar, G. Suresh and R.C. Singh)

2.5 Production potential of drumstick (*Moringa oleifera*) based hortipastoral system for periodically inundated land

(Sudhir Kumar, Sunil Kumar, R.C. Singh and M.P. Rai)

2.6 Effect of basin size and nurse crop on fruit crops under hortipastoral systems

(R.C. Singh, Sudhir Kumar and Sunil Kumar)

GSM 3 : Revegetation of degraded rangelands/wastelands and grazing management

3.1 Management of shrub infested grassland through mixed herd grazing

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

3.2 Pilot project on Revegetation of Ravines for increased quality forage and fuelwood production

(B.K. Trivedi, S.K. Soam, P.K.Sahoo and U.B.Choudhary)

3.3 Revegetation of degraded rangelands

(S.K. Soam, B.K. Trivedi and Vinod Shankar)

3.4 Effect of planting pattern and harvest frequencies on legumes performance in mixed pasture

(S. Ram and Vinod Shankar)

GSM 4 : Rangeland surveys and evaluation of forage resources

4.1 Geomorphological and grazing resource inventory of lower Sind catchment

(J.P. Singh and Dipankar Saha)

GSM 5 : Ecology and potentials of rangeland species particularly shrubs and under-utilized Species

5.1 : Survey, evaluation and maintenance of non-conventional and under-utilized species

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

5.2 Identification of factors responsible for formation of pure germinating seeds in range/cultivated grasses

(S.S. Parihar and Anjali Kak)

5.3 : Studies on grass legume interference

(S.S. Parihar and Shivnath Ram)

PLANT ANIMAL RELATIONSHIP

PAR 1 : Nutritional evaluation

1.1 Developement of effecient feeding systems for dairy animals

(S.K. Mahanta, G.H. Pailan, Sultan Singh, R.S. Upadhyaya, K.K. Singh and V.C. Pachauri)

1.2 Nutritional evaluation of forages using pressure transducer technique

(R. S. Upadhyaya, L.K. Karnani, S. K. Mahanta and K. K. Singh)

1.3 Influence of fibre fractions of range grasses and legumes on the availability of macro minerals

(K.K. Singh)

1.4 Studies on relationship between intake and

physico-chemical characteristics of new forage varieties

(V.C. Pachauri, S.K. Mahanta and Sultan Singh)

PAR 2 : Livestock production management

2.1 On farm trials on silage making/ improvement of low grade roughages

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

2.2 Response of animals fed on ammoniated low grade roughages

(A.B. Mojumdar, A.P. Singh and A.K. Mishra)

2.3 Utilization of shrubs and tree leaves as animal feed

(V.S. Upadhyaya, P.N. Diwedi, A.B. Mojumdar and B.K. Bhadoria)

PAR 3 : Forage quality evaluation

3.1 Secondry metabolites as feed deterents in natural shrubs

(B.K. Bhadoria, A.S.Negi,S.K. Nag, R.S. Upadhyaya and A.B. Mojumdar)

SEED TECHNOLOGY

SPR 1 : Crop geometry, fertilizer use and moisture stress in relation to seed production in forage crops

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

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

1.2 Agronomical investigation in pasture legume seed production

(G.K. Dwivedi, S.M. Misra and L.P. Misra)

1.4 Agronomic investigation for increasing seed yield in grasses

(G.K. Dwivedi and Dinesh Kumar)

1.5 Studies on Potassium nutrition to perennial seed crops

(S.M.Mishra and G.K.Dwivedi)

1.6 Effect of cutting management, irrigation schedule and exogenous chemical spray on seed production of berseem (*Trifolium alexandrium*)

(L.P.Misra and Dinesh Kumar)

1.7 Impact of pollen kit variation on seed production of forage legume,alfalfa(*Medicago sativa*)

(K.Sridhar, Ch. Padmavathi and C.B.Singh)

1.8 Effect of seed size and seed rate on seed production of forage crops

(Dinesh Kumar and Rakesh Seth)

SPR 2 : Seed-borne diseases and their control in forage crops

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

(S.N. Singh and Ch. Padmavathi)

SPR 3 : Insect-pest and pathogens in seed storage

3.1.1 Effect of containers and pesticides on the incidence of storage pests and pathogens and storability of Albizia and Clitoria seeds

(S.N. Singh, A.A. Khan, Ch. Padmavathi and Rakesh Seth)

3.1.2 Effect of botanicals on insect pest and pathogens and germinability in Albizia and Clitoria seeds

(S.N. Singh, A.A. Khan, Ch. Padmavathi and Rakesh Seth)

3.2 Relative efficiency of biotic and abiotic agents as pollination facilitators in quality seed production of lucerne (*Medicago sativa* L.)

(Ch. Padmavathi,Rakesh Seth and K.C.Pandey)

SPR 5 : Seed quality control and testing

5.3 Germinability and seedling vigour of forage seeds harvested at different stages of maturity

5.3.1 Germinability and vigour studies in cowpea *(Vigna unguiculata)* seeds

(Rakesh Seth , Ch. Padmavathi and L. P. Misra)

5.4 Responses of foliar applied growth regulators and nutrients on forage and seed yield in grasses and legumes

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

FARM MACHINERY & PHT

1.2 Feasibility testing of improved implements on farmers field

(R.B. Varshney, M.B. Tamhankar and Brajesh Singh)

1.3 Development of Power operated tyre type seed pelleting machine

(P.D. Gupta and Brajesh Singh)

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

(P.D. Gupta, P.S. Chattopadhyay and V.C. Pachauri)

2.1.2 Performance evaluation of feed pelleting machine

(P.D.Gupta, M.B. Tamhankar and V.C. Pachauri)

3.1 Studies on the interaction of conservation practices and animal grazing on run off and soil loss under different grazing system under NCP

(R.B. Varshaney)

SOCIAL SCIENCES

EE 1 : Analysis of farm management and economics of forage production system and utilization

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

(R.A.Singh and P.Ranjitha)

1.2 Socio-economic analysis of the NWDB project in the Bundelkhand region- site Ambabai village

(R.A. Singh and Isabella Agarwal)

1.3 Impact of technology adoption on resource productivity and allocative efficiency in milk production in the Bundelkhand region of UP

(Sandeep Saran, Isabella Agarwal and K.K. Singh)

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

(Ashok Kumar and Rakeah Kumar)

1.5 Analysis of farm income and employment on forage dominated croppind pattern in Shivpuri district of Madhya Pradesh

(Mallya, R.N.Dwivedi and Ashok Kumar)

1.6 Economics of crop based livestock production system under different grazing management systems under NCP

(P. Ranjitha)

EE 2 : Adoption and diffusion of forage innovations and feed back information

2.1 Evaluation of forage farming systems at farmers field

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

2.2 Participatory research at farmers fields through participatory rural appraisal (PRA)

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

2.3 Assessment of knowledge of forage production practices and constraints faced by farmers and farm women

(Manju Suman, Mallya, Isabella Agarwal and Mahavir Singh)

2.4 Impact of demonstraction on participant and non-participant farmers

(Mahavir Singh, Atar Singh, P. Ranjitha and Manju Suman)

RRC, DHARWAD

SRS 2: Studies on agronomic aspects of perennial cereal legume intercropping systems and agrosilvipastoral systems

(B. Gangaiah and C.R. Ramesh)

SRS 3: Varietal evaluation of cultivated forage crops under on-station and co-ordinated trials

(D.H. Sukanya, C.R. Ramesh and V. Ramamurthy)

SRS 4: Genetic improvement of fodder bajra (*Pennisetum americanum*) and bajra x Napier(*P.pedicellatum*) hybrids for quality and productivity

(D.H. Sukanya, V. Ramamurthy and C.R. Ramesh)

SRS 8 : Monitoring of diseases and insect pests of natural and cultivated fodder in different cropping systems

(C.R. Ramesh, V. Ramamurthy and D.H. Sukanya)

SRS 9: Assessment of diseases and their control in major pasture legume seed production

(C.R. Ramesh and V. Ramamurthy)

SRS 10 : Participatory planning and its impact on improving forage resources of milkshed & nonmilk shed areas of Dharwad taluk

(Nagratna Biradar,C.R. Ramesh, V. Ramamurthy and D.H. Sukanya)

SRS 11 : Effective utilization of bunds for fodder production in small holder farming systems

(V. Ramamurthy, D.H. Sukanya,C.R. Ramesh, and B. Gangaiah)

SRS 12 : Development of production technology for mass multiplication of napier bajra (*Pennisetum pedicellatum*)

(V.Ramamurthy,D.H.Sukanya and B.Gangaiah)

RRC, AVIKANAGAR

WRS 1 : Network collaborative programme (NCP) on crop based animal production systems

(R.K. Jain and H.N. Subudhi)

WRS 2 : Studies on the role of VAM fungi in management of root-knot nematodes on berseem, lucerne and cowpea(Cess fund project)

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

WRS 3 : Collecton and evaluation of Ailanthus spp for silvopasture systems under semi arid regions(Cess fund project)

(R.K. Jain, Jiban Mitra and H.N. Subudhi)

WRS 4 : Quality seed production of range grasses(Revolving fund project)

(R.K. Jain)

WRS 5 : Aonla (*Emblica officinalis*) based hortipastoral system for maximization of food fodder system

(R.K. Jain)

WRS 6 : Maximization of food,fodder fuel through agroforestry system

(R.K. Jain,J. Mitra and H.N. Subudhi)

WRS 7 : Collecton ,evaluation and selection of *Indigofera linofolia* for improved forage yield

(J. Mitra and H.N. Subudhi)

WRS 8: Studies on the forage and weed flora of Malpura & adjoining area

(H.N. Subudhi and J. Mitra)

RRC, PALAMPUR

TRC-1 : Production potential of mid hill grasslands

(B.K. Misri and Sindhu Sareen)

TRC-2 : Genetic improvement of white clover (*Trifolium repens*) for quality persistence and higher herbage production in the Himalayan pastures.

(Sindhu Sareen, B.K. Misri and Inder Dev)

11. RAC, MANAGEMENT COMMITTEE, SRC. QRT

SRC

The SRC meeting was held from May 15-17,1997 under the chairmanship of the Director. Eminent outside experts namely, Prof. V.P.Gupta, PAU, Ludhiana and Dr. S.K. Aroara, HAU, Hissar also participated. The significant decisions are :

- It is mandatory that all the projects of the Institute should fall under Institute's nine identifed programme areas which are embraced in the Institute's Perspective Plan(Vision 2020).
- Cess Fund project and Revolving Fund schemes should be given top priorty in order to further stregthen the Institute's research infrastructure and facilities.
- The scientists who had undergone PRA training under Indo-UK Forage Project should initiate PRA work at IGFRI.

QRT

The Quinquennial Review Team(QRT) constituted for reviewing the activities of the IGFRI comprised of the Chairman - Dr. B.K. Soni and members,viz., Dr. B.D. Patil, Dr. V.P. Gupta, Dr. G.P. Lodhi, Dr. N.P. Melkania and Dr. B.M. Singh. The committee recommended, "THE IGFRI SHOULD LEAD NOT FOLLOW IN BASIC AND APPLIED RESEARCH ON GRASSLANDS AND FODDER CROPS IN THE COUNTRY."The research should emphasise the linkage Soil ↔ Plant ↔ Animal ↔ Human. Major emphasis needs to be given to problem solving research particularly the rainfed marginal arable lands, natural grasslands and degraded lands in various agro-climatic zones of the country.

The IGFRI should stregthen the following area-specfic research centres to work on the problems of specific ecological regimes.

- Centre for Research on Sub-humid Tropical Grasses and Legumes
- Centre for Research on Arid and Semi-arid trees,Grasses and Legumes
- Centre for Research on Sub-Temperate Grasslands
- Centre for Research on Wetland Grasses and Legumes

RAC

The RAC meeting held on 13-14May,1997 under the Chairmanship of Dr. R.P. Singh, Ex-Director, CRIDA and Dr. K.L. Mehra, Dr. S.K. Arora, Dr. M. Ahluwalia and Dr. J.P. Tandon (ADG - FC) as external members. The broader areas were identified in the field of Resourse generation, Consultancy areas, Coordinated/externally aided projects and Farmers' participatory rural appraisal. The members gave valuable suggestions on 'IGFRI Vision 2020'.

Management Committee

The Management Committee meetings were held on 9.1.1997 and 19.12.1997, respectively under the chairmanship of Dr. Bhag Mal.

12. WORKSHOPS, SEMINARS, SUMMER INSTITUTES, FARMER'S DAY

During the period under report, following workshops, seminars, symposia, workshops and Farmer's Day were organised:

1.	Workshop on Network Collaborative Programme on Crop based Animal Production Systems	September 9-10,1997
2.	Group meeting of AICPRP on Forage Crops	September 15-16,1997
3.	Satellite Workshop on Stylosanthes	September 17,1997
4.	Kisan Gosthi	October 18,1997
5.	Mahila Diwas(Women in Agriculture)	October 18,1997
6.	Workshop on Client Orientation and Technology on the Shelf	November 17-22,1997
7.	Workshop on Fodder Research and Livestock Development - New Vistas	December 20-22,1997
8.	Workshop on Farm Research	March 2-4,1998
9.	Workshop on Participatory Plant Breeding	March 5-11,1998
10.	Farmer's Day	March 19,1998

13. DISTINGUISHED VISITORS

Dr. Mangla Rai
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Deputy Director General (AS)
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Dr. Arun Verma
Asstt. Director General (AN & P)
ICAR, Krishi Bhawan
New Delhi 110 001

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London, UK

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IGER, Dyfed SY23 3EB
Aberystwyth, UK

Prof. R. J. Haggar
IGER, Dyfed SY23 3EB
Aberystwyth, UK

Dr. Tom Farrington
ITAD, Lion House,
Ditchley Common Trading Estate,
Hassocks, West Sussex, BNG 8SL, UK

Dr. R.P. Singh
Ex-Director, CRIDA
61, Sardar Club
Jodhpur

Dr. John Farrington
ODI,
London, UK

Dr. R.N. Singh
Director
CSWRI, Avikanagar

Shri Kulbant Rai Verma
Swami Kumarnand Bhawan
Hathoi Road, Near Shalimar Cinema
Jaipur

Shri Ramashish Yadav
Village Loma, Post- Salempur
Via Benapatti,
District Madhubani

Shri P.D. Sudhakar, IAS
Commissioner
Jhansi Division, Jhansi

Dr. K.L. Mehra
38, Munirka Enclave
New Delhi 110067

Dr. M. Ahluwalia
D-32, Greator Kailash,
Enclave- II
New Delhi 110 048

Dr. S.K. Arora
748, Sector 15A,
HAU, Hissar 125 001

Dr. V.P. Gupta
Professor and Head of Deptt.
PAU, Ludhiana 141 004

Dr. Salisu A. Shadm
Sokoto Agricultural and Community Development Project
Sokoto, Nigeria

Dr. Abubakar S. Sifawa
Sokoto Agricultural and Community Development Project
Sokoto, Nigeria

Dr. M. L. Gupta
University of Queensland
Gatton Cellose, Australia

Ms. Natasha Landell Mills
ODI,
London, UK

Dr. A. Rekib
Director
CIRG, Makhdoom

Dr. N. P. Melkania
North Eastern Region Institute of Science and Technology, Itanagar
Arunachal Pradesh

Dr. John Dane
Director
ICRA, Wageningen
The Netherlands

Prof. R.C. Yadav
Director
Bundelkhand Institute of Engg. & Tech.
Jhansi

Dr. Robert Moss
EDG.
Oxford, UK

Bob Clements
IGER, Dyfed SY23 3EB
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Mike Theodorou
IGER, Dyfed SY23 3EB
Aberystwyth, UK

Merwyn Humphreys
IGER, Dyfed SY23 3EB
Aberystwyth, UK

William Eason
IGER, Dyfed SY23 3EB
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Professor Don Loch
CSIRO, Australia

Dr. John Witcombe
University of Wales
UK

Mr. Peter Swinburne
Institute Secretary
IGER, Dyfed SY23 3EB
Aberystwyth, UK

Dr. R.O. Clements
IGER, Dyfed SY23 3EB
Aberystwyth, UK

Dr. T. Tafrey
IGER, Dyfed SY23 3EB
Aberystwyth, UK

Dr. John Morrison
FAO, Rome

Dr. R.D. Sharma
Director (Publications)
ICAR, Krishi Anusandhan Bhawan
Pusa Campus, New Delhi

Shri Ratan Prakash
CPRO,
ICAR, Krishi Bhawan
New Delhi

Media Team comprising eleven representative of National News Papers from New Delhi

14. VISITS ABROAD

The following scientists/officers visited abroad during 1997-98 :

Name	Period	Place
Dr. R.K. Bhatt, Scientist	5.5.97-4.9.97	UK
Dr. A.K. Misra, Scientist	5.5.97-4.9.97	UK
Shri Vishnu Bhatt, Scientist	5.5.97-4.11.97	UK
Dr. Bhag Mal, Director	8.6.97-19.6.97	Canada
Dr. Vinod Shankar, Principal Scientist	8.6.97-19.6.97	Canada
Dr. V. S. Upadhyaya, Principal Scientist	8.6.97-19.6.97	Canada
Ms. Seema Srivastava, Sr. Technical Assistant	14.6.97-13.7.97	UK
Dr. C.R. Hazara, Project Coordinator (FC)	22.6.97-28.6.97	Germany
Shri A.K. Srivastava, Sr. Technical Officer	5.7.97-6.8.97	UK
Shri Dodamani Amalappa, Instrumentation (T-7)	5.7.97-6.8.97	UK
Dr. L.P.Misra, Principal Scientist	2.8.97-18.8.97	UK
Dr. P.D. Gupta, Principal Scientist	2.8.97-18.8.97	UK
Dr. V.C. Pachauri, Principal Scientist	2.8.97-18.8.97	UK
Shri D.S. Katiyar, Scientist	9.9.97-19.9.97	China
Dr. A.K. Patra, Scientist	13.9.97-19.9.97	Japan

15. PERSONNEL

Director **Dr. Bhagmal, Ph.D.**

I. SCIENTIFIC

Division of Crop Improvement

S.T. Ahmad, Ph. D., Principal Scientist (Plant Pathology) & Head of Division (Upto 31.12.97)
S.N. Zadoo, Ph. D., Principal Scientist (Gent. & Cytogenetics) & Head of Division (w.e.f. 1.1.98)
C.B. Singh, Ph.D., Sr. Scientist (Plant Breeding)
R.N. Choubey, Ph.D., Sr. Scientist (Plant Breeding)
S.N. Tripathi, Ph.D., Sr. Scientist (Genetics & Cytogenetics)
Devendra Singh, M.Sc., Sr. Scientist (Plant Breeding)
O. P. S. Verma, M.Sc., Sr. Scientist (Planl Physiology)
S.A. Faruqui, Ph.D., Sr. Scientist (Entomology)
M.I. Azmi, Ph.D., Sr. Scientist (Nematology)
M.G. Gupta, Ph.D., Sr. Scientist (Genetics & Cytogenetics)
K. C. Pandey, M .Sc., Sr. Scientist (Entomology)
N. Hasan, Ph.D., Sr. Scientist (Nematology)
O.P. Dixit, M.Sc., M.S.(PGR), Sr. Scientist(Plant Breeding)
U.P. Singh, M.Sc., Sr. Scientist (Economic Botany)
B.S. Chaudhary, M.Sc., Sr. Scientist (Plant Breeding)
K.S. Kohli, Ph.D., Sr. Scientist (Plant Breeding)
D. N. Singh, Ph. D., Sr. Scientist (Plant Breeding)
R.B. Bhaskar, M.Sc., Sr. Scientist (Plant Pathology)
U. S. Mishra, M.Sc., Scientist Sr.scale (Plant Breeding)
D.R. Malaviya, Ph.D., Scientist Sr.scale (Plant Breeding)
N.K. Shah,Ph.D., Scientist Sr.scale (Entomology)
Pradeep Saxena, Ph.D., Scientist Sr.scale (Plant Pathology)
Ajoy Kumar Roy, Ph.D., Scientist Sr.scale (Genetics & Cytogenetics)
Amresh Chandra, Ph.D., Scientist Sr.scale (Bio-Chemistry)
Sharmila Roy, M.Sc., Scientist (Entomology)
Sanjeev Gupta, M.Sc., Scientist (Plant Breeding)
Sanjay Gupta, M.Sc., Scientist (Genetics & Cytogenetics)(study leave)
Ms. M. Anuradha, Ph.D., Scientist Sr.scale (Plant Pathology)
Vishnu Bhatt, M.Sc., Scientist (Plant Breeding)
B. Venktesh Bhatt, M.Sc., Scientist (Plant Breeding)
D.K. Agarwal, M.Sc., Scientist (Plant Breeding)
P.K. Katiyar, Ph.D., Scientist (Plant Breeding)
P.K. Mandal, Ph.D., Scientist (Plant Biochemistry)
M.S. Saharan, M.Sc., Scientist (Plant Pathology)(study leave)

Ms. C.N. Neeraja, M.Sc., Scientist (Genetics & Cytogenetics)
Mrs. Anjali Chatrath, Ph.D., Scientist (Plant Physiology)
M.J. Baig, Ph.D., Scientist (Plant Physiology)
P. Kaushal, Ph.D., Scientist (Genetics & Cytogenetics)
S.V. Sai Prasad, Ph.D., Scientist (Plant Breeding)

Division of Crop Production

P.S. Tomer, Principal Scientist (Agronomy) & Head of Division
A.S.Gill, Ph.D.,Principal Scientist (Agronomy)
N.P. Shukla, Ph.D., Sr. Scientist (Agronomy)
M.R. Pahwa, Ph.D., Sr. Scientist (Microbiology)
O.P.S. Panwar, M.Sc., Sr. Scientist (Soil Science)
S.N. Tripathi, M.Sc., Sr. Scientist (Agronomy)
S.B. Tripathi, Ph.D., Sr. Scientist (Soil Science)
Pradeep Behari, M.Sc., Scientist Sr.scale (Ag. Meteorology)
Banwari Lal, Ph.D. Scientist Sr.scale (Agronomy)
R.B. Yadava, Ph.D., Scientist Sr.scale (Soil Science)
K.P. Niranjan, M.Sc., Scientist Sr.scale (Agronorny)
Atar Singh, Ph.D., Scientist Sr.scale (Agronomy)
S.D. Gupta, M.Sc., Scientist Sr.scale (Agronomy)
R.L. Arya, Ph.D., Scientist Sr.scale (Agronomy)
A.K. Patra, Scientist Sr.scale (Soil Science)
K.C. Sharma, M.Sc., Scientist (Agronomy)
R. K. Agarwal Ph.D., Scientist (Agronomy)
J.B. Singh, Ph.D., Scicntist (Ag. Meteorology)
S.K. Das, Ph.D., Scientist (Ag. Chemistry)
K. Shankarnarayan, M.Sc., Scientist (Agronomy)(study leave)
S.K. Rai, M.Sc., Scientist (Ag. Meterology)
D. Burman, Ph.D., Scientist (Soil-Water Conservation)
Shiv Dhar, Ph.D., Scientist (Agronomy)
J.V.S.N. Prasad, M.Sc., Scientist (Agronomy)

Division of Grassland and Silvopasture Management

Vinod Shankar, Ph.D., Principal Scientist (Economic Botany) & Head of Division(upto 1-9-97)
B.K. Trivedi, Ph.D., Sr. Scientist (Economic Botany) & Head of Division(w.e.f. 2-9-97)
J.N. Gupta, Ph.D., Sr. Scientist (Economic Botany)
R.C. Singh, Ph . D., Sr. Scientist (Agronomy)
M.M Roy, Ph.D., Sr. Scientist (Economic Botany)
S.S. Parihar, Ph.D, Sr. Scientist (Economic Botany)
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S.K. Sharma, Ph.D., Scientist Sr.scale (Horticulture)
T.A. Khan, M.Sc., Scientist Sr.scale (Statistics)

Jai Prakash Singh, Ph.D., Scientist Sr.scale (Economic Botany)
J.P. Singh, Ph.D., Scientist (Geography)
Shiv Nath Ram, M.Sc., Scientist (Agronomy)
Dipankar Saha, M.Sc., Scientist (Economic Botany)
S.K. Soam, Ph.D., Scientist (Economic Botany)
Sudhir Kumar, Ph.D., Scientist (Horticulture)
Sunil Kumar, Ph. D., Scientist (Horticulture)
G. Suresh,Ph.D., Scientist (Agronomy)

Division of Plant Animal Relationship

V.C. Pachauri, Ph.D., Principal Scientist (Animal Nutrition) & Head of Division
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V.S. Upadhyay, Ph.D., Principal Scientist (LPM)
R.S. Upadhyay, Ph.D., Sr. Scientist (Animal Nutrition)
N.C. Verma, Ph.D., Sr. Scientist (LPM)
A. B . Majumdar, Ph .D., Sr. Scientist (Bio-Chemistry)
B.K. Bhadoria, Ph.D., Sr. Scientist (Organic Chemistry)
L.K. Karnani, M.Sc., Scientist Sr.scale (Agricultural Chemistry)
N.P. Singh, M.Sc., Scientist (LPM), (study leave)
S.B. Maity, M.Sc., Scientist (LPM), (study leave)
A.K. Mishra, Ph.D., Scientist (LPM)
K.K. Singh, Ph.D., Scientist (Animal Nutrition)
M.M. Dass, M. V. Sc., Scientist (Animal Nutrition), (study leave)
A.K. Samanta, Ph.D., Scientist (Animal Nulrition)
Sultan Singh, Ph.D., Scientist (Animal Nutrition)
S.K. Mahanta, Ph.D., Scientist (Animal Nutrition)
Ms. Jyotsna Bahal, Ph .D., Scientist (Biochemistry)
A.S. Negi, M.Sc., Scientist (Organic Chemistry)
F.C. Tuteja, M.V.Sc., Scientist (Vet. Medicine), (study leave)
S.K. Nag, Ph.D., Scientist (Agricultural Chemistry)
G.H. Pailan, M.Sc., Scientist (Animal Nutrition)

Division of Seed Technology

L.P.Misra, Ph.D.,Principal Scientist (Plant Physiology), Head of Division
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S.M.Misra, Ph.D., Sr.Scientist (Soil Science)
K.P.Singh, Ph.D., Scientist Sr.scale (Cytogenetics)
G.K.Dwivedi, M.Sc., Scientist Sr.scale (Agronomy)
R.K.Bhatt, Ph.D., Scientist Sr.scale (Plant Physiology)
Rakesh Seth, Ph.D., Scientist (Seed Technology)
Ch.Padmavathi, Ph.D., Scientist (Entomology)

Dinesh Kumar, Ph.D., Scientist (Agronomy)
Aruna Kishor, Ph.D. Scientist (Plant Pathology)

Division of Agricultural Engineering

P.D. Gupta, Ph.D., Principal Scientist (FMP) & Head of Division
R.B. Varshney, B.Tech., Sr.Scientist (Soil Water Engineering)
P.S. Chattopadhyay, M.Tech., Scientist (FMP)
R. K. Goyal, M.Tech., Scientist (Ag. Strucl. & Proc. Engg.)
M.L.Gaur,B.Tech.,Scientist (Ag. Strucl. & Proc. Engg.) (upto 23.7.98)
M.B.Tamhankar, B.Tech., Scientist (FMP), (study leave)
P.K. Pathak, M. Tech., Scientist (Ag. Strucl. & Proc. Engg.), (study leave)
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Anil Kumar, M.Sc., Scientist (LPM), (study leave)
K. Shankarnarayan, M.Sc., Scientist (Agronomy)(study leave)

Division of Economics and Extension

Atar Singh, Ph.D., Principal Scientist (Agronomy) & Head of Division
R.N. Dwivedi, M.Sc., Sr. Scientist (Agronomy)
Mallaya, Ph.D., Sr. Scientist (Economics)
Maharaj Singh, Ph.D., Scientist Sr.scale (Extension)
Ram Ashrey Singh, M.A., Scientist Sr.scale (Economics)
Ashok Kumar, M.Sc., Scientist Sr. scale (Statistics)
Mahavir Singh, M.Sc., Scientist Sr. scale (Extension)
Mrs. Manju Suman, Ph.D., Scientist Sr. scale (Extension)
R.V. Singh, M.Sc., Scientist (Extension)(study leave)
Mrs. Ranjitha P., Ph.D., Scientist (Agricultural Economics)
Mrs. Isabella Rani Agarwal, M.Sc., Scientist (Agricultural Economics)(study leave)
Purushottam Sharma, M.Sc., Scientist (LPM)(study leave)

Division of Informatics and Support Services

R.K. Tyagi, Ph.D., Sr. Scientist (Geography) & Head of Division

Forage Project (Co-ordinating Unit)

N. P. Melkania, Ph.D., Project Coordinator (Forage Crops)
G.P. Shukla, Ph.D., Sr. Scientist (Plant Breeding)
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R.K.Jain, Ph.D., Sr. Scientist (Nematology)& I/C Centre
H.N. Subudhi, Ph.D., Scientist (Economic Botany)
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C.R. Ramesh,Ph.D., Principal Scientist (Plant Pathology) & I/C Centre
V. Rama Murthy, Ph.D., Sr. Scale Scientist (Agronony)
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Ms. Nagaratha P. Biradar, M. Sc., Scientist (Agricultural Extension)
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K. Sridhar, Ph.D., Scientist (Plant Breeding)

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Inder Dev, Ph.D., Scientist(Plant Breeding)

II. TECHNICAL

A.K. Srivastava, Technical Officer (T-7)
R.K. Verma, Veterinary Officer (T-7)
M.S. Sharma, Farm Manager (T-7)
Dodamani Amallappa, Instrumentation (T-7)
V.K. Litoria, Medical Officer(T-6)
N.C..Srivas, Technical Officer (T-6)
G. R. Deshmukh, Technical Officer (T-6)
S.K. Rajpali, Technical Officer (T-6)
M.M. Rastogi, Technical Officer (T-5)
R.B. Mathur, Technical Officer (T-5)
D.K. Bhutani, Technical Officer (T-5)
Ravindra Pal Singh,Technical Officer (T-5)
Shree Ram Sikanya, Technical Officer (T-5)
C.P. Gupta, Technical Officer (T-5)
Mahi Pal Singh, Farm. Superintendent (T-5)
H.N. Sharma, Tcchnical Officcr (T-5)
B.L. Barodia, Technical Officer (T-5)

Pramod Kumar Dwivedi,Tcchnical Officer (T-5)
Ram Singh,Technical Officer (T-5)
Gyasi Lal,Technical Officer (T-5)
Kanhai Singh,Technical Officer (T-5)
G.P. Nigam,Technical Officer (T-5)
O.N. Arya, Technical Officer (T-5)
P.K. Karpe,Technical Officer (T-5)
S.C. Richharya (T-5)
Indra Pal Singh (T-5)
Rajendra Singh Parihar (T-5)
Nar Singh (T-5)
Raj Kumar Sharma (T-5)
Sandhya Bhargava (T-5)
R.P. Yadava (T-5)
Anil Kumar Srivastava (T-4)
Sunil Gupta (T-4)
H.K. Agarwal (T-4)
R.B. Bhondele (T-4)
P.K. Tyagi (T-4)
K.P. Rao (T-4)
Ms. Seema Srivastava (T-4)
S.D. Singh (T-4)
A.K. Saxena (T-4)
O.P. Singh (T-4)
H.K. Agarwal (T-4)
B.K. Pandurangh (T-4)
Mathura Prasad (T-4)
R.N. Niranjan (T-4)
Asha Ram (T-4)
Narain Dass (T-4)
Tirath Raj (T-4)
Malkeet Singh (T-4)
Laxmi Narayan (T-4)
V.D.Chabra (T-4)
Anita Savnani (T-4)

III. ADMINISTRATIVE

Sanjay Kant, Senior Administrative Officer
D.D. Verma, Sr. Finance and Accounts Officer
H.C. Saxena, Administrative Officer

Gauri Shankar, Asstt. Administrative Officer
L.S. Sharma, Asstt. Administrative Officer
O.P. Dubey, P.A. to Direclor
S.N. Dubey, Superintendent
G. D. Dubey, Superintendent
Mrs. S.L Hukmani, Superintendent
Mrs. N. Arora, Superintendent
A.N. Nimje, Superintendent
N.L. Sinoriya, Superintendent
P.B. Nair, Senior Stenographer
C. Narayan, Senior Slenographer

सारांश

संस्थान ने वर्ष 1997-98 में चारा उत्पादन एवं उपयोग के क्षेत्रा में महत्वपूर्ण अनुसंधान कार्य किये हैं। अनुसंधान उपलब्धियों का सारांश निम्नलिखित है :

फसल सुधार

आनुवांशिक संसाधन

संस्थान के पितृद्रव्यों की जैव विविधता को बढ़ाने हेतु उत्तर प्रदेश तथा मध्य प्रदेश के बुन्देलखण्ड एवं राजस्थान के मध्य क्षेत्र के जनपदों से पितृद्रव्यों का संग्रह किया गया। इलरी, इथोपिया से भी पितृद्रव्य मँगाये गये। वर्तमान संग्रह में 635 घास/गैर दलहनी चारा तथा 643 दलहनी चारे के पितृद्रव्यों की बढ़ोत्तरी की गयी।

पादप प्रजनन

चारा उत्पादन एवं गुणवत्ता के आधार पर बरसीम की बुन्देल बरसीम-2 तथा जई की बुन्देल जई-2 किस्में विमोचित की गयीं।

लोबिया के अन्तिम मूल्यांकन परीक्षण में संस्थान की किस्म आई.एफ.सी.–9503 से अधिकतम (30 टन/हे.) हरा चारा प्राप्त हुआ। संस्थान की दूसरी किस्म आई. एफ.सी.–9502 से 27.5 टन/हे. हरा चारा प्राप्त हुआ, जबकि मानक किस्म बुन्देल लोबिया–1 से 24.8 टन/हे. हरा चारा प्राप्त हुआ।

बरसीम की टेट्राप्लॉइड किस्में जे.एच.टी.बी.-96-4 तथा 96-5 ने अखिल भारतीय परीक्षणों में क्रमशः प्रथम व द्वितीय स्थान पर रहीं। संस्थान से अखिल भारतीय परीक्षणों में नयी दो डिप्लॉयड (जे.एच.बी.–97-1 तथा 97-2) एवं दो टेट्राप्लॉइड (जे.एच.टी.बी.–97-3 तथा 97-4) किस्में भी इस वर्ष सम्मिलित की गई।

संस्थान द्वारा विकसित चारा सेम की किस्में एल.पी. –27 तथा एल.पी.एस.–2 ने अखिल भारतीय परीक्षणों में मानक किस्म (बुन्देल सेम–1) से क्रमशः 11.0 तथा 9.0 प्रतिशत अधिक उत्पादन दिया।

अंजन घास की इगफ्री–3133, 675 तथा 8-4-3 किस्मों ने अखिल भारतीय परीक्षणों में हरा तथा शुष्क चारा उत्पादन में अच्छा प्रदर्शन किया।

अपराजिता की किस्म इगफ्री 23-1, 173-1 तथा 7-3 से अखिल भारतीय परीक्षणों में अन्य किस्मों की तुलना में अधिक हरा तथा शुष्क चारा उत्पादन हुआ।

आनुवांशिकी एवं कोशानुवांशिकी

जई की दो भिन्न जातियों *एविना सटाइवा* तथा *एविना मेरोकेना* के संकरण से प्राप्त संततियों की F_{12} पीढ़ी में गुणसूत्राों में स्थायित्व पाया गया है। इन संततियों में अन्य विमोचित प्रजातियों से बहुकटीय आधार पर अधिक चारा उत्पादन सम्भव हुआ है।

आइसोजाइम विश्लेषण के आधार पर यह सुनिश्चित किया गया है कि *पेनीसेटम वाइओलेसियम* एवं *पेनीसेटम ग्लाउकम* का अत्यन्त निकट सम्बंध है तथा दो अन्य जातियाँ *पेनीसेटम स्क्वामुलेटम* तथा *पेनीसेटम परपुरियम* भी सम्बंधित हैं।

आक्सिन प्रेरित पार्थेनोकारपी परीक्षण और पिस्टल क्लियरिंग तकनीक द्वारा लैंगिक प्रजनन क्षमता के निरीक्षण द्वारा यह स्पष्ट हुआ है कि *सैंक्रस प्रियुरी* में पूर्णतः लैंगिक प्रजनन क्षमता है तथा संकर *सैंक्रस* पौधे तथा *सैंक्रस सिलियेरिस* के दो पित्रृकों में विकल्पी लैंगिक प्रजनन क्षमता है। *सैंक्रस इकानेटरस* में पूर्णतः

लैंगिक प्रजनन क्षमता पिस्टल क्लियरिंग तकनीक द्वारा जाँची गयी है।

पादप संरक्षण

ज्वार में एन्थ्रकनोज बीमारी का अगस्त के अंतिम पखवारे में सर्वाधिक प्रकोप पाया गया है। पाँच नीम आधारित उत्पादों के तुलनात्मक अध्ययन से यह स्पष्ट हुआ है कि करक जालिका वृद्धि तथा बीजाणु अंकुरण क्षमता को रोकने में 2 प्रतिशत नीम बीज का आसवन (एन.एस.के.ई.) सर्वाधिक सक्षम है।

लोबिया में जड़ मूल विलगन व्याधि के विरूद्ध जैविक नियंत्रण के रूप में वाम कवक तथा नीम की खली का एक साथ उपयोग लाभदायी सिद्ध हुआ है। इससे पोषक तत्वों के उपयोग में भी वृद्धि हुई है। आर.एफ.सी. –9702 एवं सी.एल.–373 प्रजातियां *मेलाइडोगाइन इनकोग्नीटा* तथा *मेलाइडोगाइन जवानिका* नामक सूत्राकृमियों के प्रकोप से प्रतिरोधी पायी गयी है। एण्डोसल्फान अवशेष की अवक्षरण दर प्रथम स्तर की पायी गयी है। इसके अवशेष का अर्धजीवन एवं सुरक्षित प्रतीक्षा अवधि क्रमशः 4 एवं 14 दिन पाये गये हैं ।

लोबिया + ज्वार – बरसीम + जापानी सरसों के फसलचक्र में नीम केक द्वारा मृदा उपचार तथा कारबोफुरान, बेविस्टन + थीरम द्वारा बीजोपचार प्रक्रिया से सर्वाधिक हरा चारा उत्पादन (187.61 टन/हे./वर्ष) सम्भव हुआ है जो कि मानक उपचार की तुलना में 18 प्रतिशत अधिक रहा है।

पादप दैहिकी एवं जैव रसायन

हाइड्रेटेड–डिहाइड्रेटेड ज्वार (एच.सी.–136) के बीजों में कैल्शियम हाइपोक्लोराइट द्वारा एक घंटे तक उपचार से निम्नतम साल्यूट लीकेज एवं लिपिड परऑक्सीडेशन पाया गया है। उपचारित बीजों में 100 प्रतिशत अंकुरण क्षमता पायी गयी जबकि नियंत्रित उपचार में यह 96 प्रतिशत थी।

लोबिया में पोटेशियम आयोडाइड द्वारा दो घंटे के उपचारित बीजों में निम्नतम साल्यूट लीकेज (36.84 प्रतिशत) एवं लिपिड परऑक्सीडेशन हुआ है। इस उपचार से 100 प्रतिशत बीज अंकुरण प्राप्त हुआ।

जैव प्रौद्योगिकी

रिजका के विभिन्न एक्सप्लांट जैसे वृत्त, हाइपोकोटाइल, काटीलिडन, नोड, पत्ती तथा बीजों द्वारा एम एस एवं एस एच संवर्धन माध्यम में पौधों के उत्पादन में सफलता अर्जित की गयी है।

केल घास में ऊतक संवर्धन जनित पौधों में अधिकाधिक विविधता पायी गयी है एवं इस प्रकार प्राप्त एस. वी. 27, एस. वी. 2, एस. वी. 20 एवं एस. वी. 7 विमोचित किस्म मार्वल 8 की तुलना में श्रेष्ठ पाये गये हैं।

एनोजियेसस पेन्डुला और संकर सुबबूल (*ल्यू. डाइवरसीफोलिया* X *ल्यू. ल्यूकोसिफेला*) में शीर्षस्थ एवं अन्तरस्थ कापिका कलिका द्वारा मल्टीपल कायिक कलिकाओं के उत्पादन में सफलता मिली है।

फसल उत्पादन

सिंचित दशा में चारा उत्पादन पद्धति

गिनी घास + लोबिया – बरसीम फसल चक्र से अधिकतम उत्पादन मिला जो कि 108.5 टन/हे. बरसीम तुल्यांक उत्पादन के बराबर रहा। रासायनिक उर्वरकों के उपयोग से अधिकतम उत्पादन (93.8 टन/हे. बरसीम तुल्यांक उत्पादन) प्राप्त हुआ।

शत–प्रतिशत रासायनिक उर्वरक अथवा 50 प्रतिशत रासायनिक तथा 50 प्रतिशत जैव उर्वरक की तुलना में शत–प्रतिशत जैव स्रोत से प्राप्त उर्वरक के उपयोग से मृदा उर्वरता में वृद्धि हुई ।

ज्वार की एच. डी.–15 किस्म से सर्वाधिक उत्पादन (40.0 हरा तथा 7.7 शुष्क टन/हे.) प्राप्त हुआ जो कि मानक किस्मों जे. एस. 10 से 13.8 प्रतिशत तथा एच. सी.–171 से 28.5 प्रतिशत अधिक रहा । अन्य बुवाई की तिथियों की तुलना में जुलाई के प्रारम्भ में बुवाई करने पर अधिक उत्पादन प्राप्त हुआ।

एकल कटाई में सिटेरिया तथा गिनी घास की तुलना में संकर नैपियर से अधिक उत्पादन प्राप्त हुआ।

ज्वार एकल तथा ज्वार + लोबिया के उत्पादन में 60 कि.ग्रा./हे. गंधक के उपचार तक वृद्धि देखी गयी। कम गंधक वाली मृदा में अधिक वृद्धि देखी गयी।

ज्वार की एच.सी.–136 किस्म से उर्वरकों की संस्तुति मात्राा (90:40:30, नत्रजन, फॉस्फेट, पोटास) के उपचार से अधिकतम उत्पादन (64.4 टन/हे. हरा व 12.8 टन/हे शुष्क चारा) प्राप्त हुआ। वर्मीकम्पोस्ट के उपयोग (7.5 टन/हे.) से भी इसी प्रकार के परिणाम प्राप्त हुये।

नत्रजन उर्वरक के साथ एजोटोवेक्टर के प्रयोग से ज्वार की उत्पादकता में वृद्धि सम्भव हुई है। इस प्रकार हरे चारे तथा शुष्क चारे में वृद्धि 112.5 कि.ग्रा./हे. हुई है। एजीटोवेक्टर रहित उपचार द्वारा 28.0 टन/हे. तथा उपचारित पद्धति में 30.6 टन/हे. शुष्क चारा उत्पादन हुआ।

रिजका में अधिक उत्पादन तथा चिरलग्नता हेतु 35 दिनों के अंतराल पर 0.75 आई.डब्लू./सी.पी.ई. अनुपात के आधार पर सिंचाई तथा 60 कि.ग्रा. पोटाश/हे. उर्वरक की संस्तुति की गयी है।

वर्षा आधारित दशा में चारा उत्पादन पद्धति

सेसबेनिया वृक्षों की वीथिका में, मक्का तथा लोबिया से हरे चारे का उत्पादन 36.4 तथा 21.7 टन/हे. तथा शुष्क चारा उत्पादन 7.8 टन/हे. और 4.4 टन/हे. हुआ। मौसमी वृत्त में (0.60 से.मी. भूमि नमी का क्षरण लोबिया के अपेक्षा मक्का के अंतर्गत अधिक पाया गया। जल आवश्यकता मक्के में (447 मि.मी.) लोाबिया (415 मि. मी.) से अधिक पायी गयी।

सेम की चारे वाली एकल फसल लेने पर सर्वाधिक हरा चारा (15.2 टन/हे.) तथा शुष्क चारा (3.3 टन/ हे.) प्राप्त हुआ। इसके उपरान्त लोबिया + अरण्डी फसल चक्र, लोबिया, सेम + अरण्ड व लोबिया + अरण्ड से सार्थक उत्पादन सम्भव हुआ है। मृदा नमी के संरक्षण उपायों में मेंड़ व नाली पद्धति (14.1 टन/हे.) से सतही बुवाई (2.1 टन/हे.) में अधिक उत्पादन सम्भव हुआ है।

उर्वरकों के प्रयोग (जैव एवं रासायनिक स्रोतों में से प्रत्येक की 50 प्रतिशत मात्राा) से केवल अकार्बनिक स्रोतों से प्रयोग की जाने वाले उर्वरकों में हरे चारे (13.7 टन/हे.) तथा शुष्क चारे में (2.8 टन/हे.) वृद्धि हुई।

ज्वार (एकल) से सर्वाधिक हरे चारे के उत्पादन (51. 25 टन/हे.) तथा शुष्क चारा उत्पादन (12.8 टन/हे.) सम्भव हुआ है। इसके उपरान्त ज्वार + लोबिया से हरा चारा (42.6 टन/हे.) तथा शुष्क चारा (12.50 टन/हे.) का उत्पादन सम्भव हुआ है। जल संरक्षण तकनीकों में जलशक्ति 5 कि.ग्रा./हे. के प्रयोग से सर्वाधिक हरा चारा (11.25 टन/हे.) तथा शुष्क चारा (11.25 टन/हे.) उत्पादन सम्भव हुआ है। इसके उपरान्त देशी हल से 3 जुलाई के बाद पाटा चलाने की विधि से भी हरे चारे (43.0 टन/हे.) तथा शुष्क चारे (10.85 टन/हे.) उत्पादन सम्भव हुआ है।

90 कि.ग्रा. नत्रजन तथा 60 कि.ग्रा. फॉस्फोरस/ हेक्टेयर के प्रयोग से सर्वाधिक हरा चारा (13.7 टन/हे.) तथा शुष्क चारा (4.5 टन/हे.) उत्पादन त्रिसंकर बाजरा + *स्टाइलोसेंथिस हमाटा* से प्राप्त है।

अंजन घास + स्टाइलो में जे.एस.आर.–4 के प्रयोग से सर्वाधिक उत्पादन (हरा चारा 6.09 टन/हे. शुष्क चारा 2.4 टन/हे.) हुआ है।

समस्याग्रस्त भूमि पर चारा उत्पादन

लवणीय क्षारीय मृदाओं में सर्वाधिक जीवता लेपरोक्लोआ (97 प्रतिशत) सम्भव हुई है। इन मृदाओं में इसके उपरान्त *ब्रेकेरिया* (96 प्रतिशत), सिटेरिया (84 प्रतिशत), क्लोरिस (80 प्रतिशत), सूडान घास (54 प्रतिशत) तथा गिनीघास (51 प्रतिशत) जीवता आँकी गयी है।

जलमग्न क्षेत्राों में पैराघास की तुलना में अलमन घास से सर्वाधिक हरा चारा (10.0 टन/हे.) तथा शुष्क चारा (3.2 टन/हे.) प्राप्त हुआ है।

कृषि – जलवायु सम्बंधी अध्ययन

बुन्देलखण्ड की मार मृदा में जल संतुलन का पिछले 20 वर्षों के साप्ताहिक विश्लेषण के आधार पर यह पाया गया कि पिछले दशक में फसल उत्पादन के विभिन्न फसल अवधि में लगभग एक सप्ताह की कमी गयी है।

बरसीम के वरदान प्रजाति में 170 दिन की फसलावधि में 758.0 मि.मी. वाष्पोत्सर्जन नापा गया है जिसका औसत 4.8 मि.मी./दिन है। इस प्रकार जल उपयोग दक्षता 24.1 कि. शुष्क पदार्थ/हे./मि.मी. पायी गयी है। मिश्रित फसली पद्धति में जल उपयोग दक्षता 15.4 कि. शुष्क पदार्थ/हे./मि.मी. पायी गयी है।

चरागाह और वन चरागाह प्रबंध

ल्यूसेना की 5 प्रजातियों के विभिन्न पितृद्रव्यों के मूल्यांकन में *ल्यूसेना कोलिन्सई* ने सर्वश्रेष्ठ प्रदर्शन किया।

अम्बावाय में शीशम आधारित वन चरागाह पद्धति से सिरिस तथा प्रोसोपिस आधारित पद्धतियों की तुलना में अधिक चारा उत्पादन मिला।

ग्रामीणों की भागीदारी से 2 हेक्टर क्षेत्र में अंजन घास – स्टाइलो चरागाह विकसित किया गया।

केन्द्रीय बकरी अनुसंधान संस्थान के बीहड़ क्षेत्रा में पाकर तदोपरान्त बबूल अच्छी तरह स्थापित हो सके। इसी प्रकार दीनानाथ घास की तुलना में अंजन घास अच्छी रही।

झाड़ियों वाले चरागाह के प्रबंध में किये जा रहे अनुसंधान के द्वितीय वर्ष में सभी पशुओं की मिश्रित चराई से ज्ञात हुआ है कि दुगने संख्या में पशुओं की चराई से झाड़ियों में कमी आयी। ऊँची झाड़ियों जो कि बकरियों की पहुँच से ऊपर थी, उन पर इसका कोई प्रभाव नहीं पड़ा।

मिश्रित चरागाह पर बुआई के तरीके तथा कटाई की संख्या के प्रभाव के अध्ययन के प्रथम वर्ष में ज्ञात हुआ कि 50 से.मी. पर 1:2 अनुपात में घास एवं दलहन की बुवाई तथा 70 दिन के अंतर पर कटाई करने से घास तथा दलहन दोनों का अधिकतम उत्पादन प्राप्त हुआ। पोटाश के प्रयोग से घास–दलहन चरागाह से उत्पादन में वृद्धि देखी गयी।

वन चरागाह पद्धति के बायोफिजीकल स्प्रेडशीट मॉडल से ज्ञात हुआ कि भूमि के नीचे के अवयव (वृक्ष की जड़े भी) घास के उत्पादन में महत्वपूर्ण भूमिका निभाते हैं।

पोषक तत्वों के उत्पादन एवं प्रकार पर किये जा रहे अनुसंधान के द्वितीय वर्ष में ज्ञात हुआ कि घास के भूमि से ऊपर वाले भाग में भूमि के नीचे वाले की तुलना में अधिक पोषक तत्व जैसे कि नत्राजन, फॉस्फोरस पोटाश व कैलशियम पाये गये। वृक्षों में सर्वाधिक पोषक तत्व पत्तियों में पाये गये तथा इससे कम मात्रा में क्रमशः जड़, टहनियों व तने में पाये गये।

चौबीस वर्ष के अंजन वृक्ष (*हार्डविकिया बाइनाटा*) (6.4 टन/हे. की) की तुलना में इसी उम्र के सिरिस में अधिक (6.6 टन/शुष्क/हे.) औसत वार्षिक पत्ती का उत्पादन पाया गया ।

बेर तथा किन्नो आधारित उद्यानी चरागाह पद्धति में अंजन घास/सेहिमा तथा स्टाइलो के मिश्रित चरागाह से अधिक उत्पादन मिला।

आंवला आधारित उद्यानी चरागाह पद्धति के द्वितीय वर्ष में आंवले की अधिकतम ऊँचाई तथा तने का व्यास क्रमशः आवंला एकल और आंवला + मखमली घास + 75 कि.ग्रा. नत्रजन/हे. में पायी गयी।

पौध पशु सम्बन्ध

जंगल जलेबी, कांकेर, मरोड़ फली, तमोई, मौली व चकेड़ी इत्यादि तलहटी झाड़ियों का टैनिन के लिए मूल्यांकन से यह निष्कर्ष निकला कि मौली व कांकेर के अतिरिक्त बाकी अन्य सभी झाड़ियों को वर्ष भर चारे के रूप में उपयोग में लाया जा सकता है।

संकर गायों पर किए गए प्रयोग से यह ज्ञात हुआ कि पशु आहार में उपलब्ध रेशे की मात्राा तथा गुणवत्ता का पशुओं में दुग्ध उत्पादन तथा मुख्य खनिजों की उपलब्धता पर कोई प्रभाव नहीं पड़ता है।

सांडों के पेट में नली डालकर किए गए अनुसंधान से यह निष्कर्ष निकला कि पशुओं के आहार में उपलब्ध अपाच्य शुष्क पदार्थ तथा रेशों (एन.डी.एफ.) (जो रयूमेन में 10 दिन इनक्यूवेट करने के पश्चात प्राप्त किया जाता है) को चराई आधारित पशुओं की शुष्क पदार्थ ग्रहणता तथा पाचकता ज्ञात करने के लिए सकेंतक के रूप में उपयोग किया जा सकता है।

बकरियों तथा भेड़ों को बकैन की पत्ती खिलाने से यह ज्ञात हुआ कि बकैन की बकरियों में ग्रहणता भेड़ों की तुलना में अधिक रही, जिसका मान क्रमशः 2.33 तथा 1.97 कि.ग्रा. प्रति 100 कि.ग्रा. शरीर भार पाया गया।

संकर बछड़ों पर किए गए प्रयोग से यह ज्ञात हुआ कि कम अन्न वाले दाना मिश्रण खिलाने से उनके वृद्धि, पोषक तत्वों की उपयोगिता तथा रक्त अवयवों पर कोई विपरीत प्रभाव नहीं देखा गया। इस प्रकार की खिलाई पद्धति को अपनाकर मनुष्यों के लिए अन्न को बचाया जा सकता है।

चराई की तीन विभिन्न पद्धतियों जैसे क्रमिक चराई, वाधित–क्रमिक चराई तथा कटाई और उठाई पद्धति में किए गए अध्ययन से यह ज्ञात हुआ कि उपरोक्त तीनों पद्धतियों में नवम्बर तक पशु के जीवन निर्वाह के लिए उपयुक्त पोषक तत्व प्राप्त हुए ।

सूखी घासों के अमोनिया उपचार से शुष्क पदार्थ की पाचकता में वृद्धि पायी गयी। जिसका मान क्रमशः 61 तथा 55 प्रतिशत था ।

ज्वार की कड़वी की छः प्रजातियों के सूखे नमूने को तथा इन्हीं के साइलेज के नमूनों को गैस उत्पादन तथा रेशे (एन.एस.पी.) की जांच से ज्ञात हुआ कि जे सेलेक्शन 4 एवं 6 अन्य नमूनों से जैविक अंश और रेशे का घुलनीकरण ज्यादा था। इसी प्रकार साइलेज के नमूनों में एस.पी.वी. 472 एवं 2077 ए एस एथेपिकम अन्य नमूनों से अच्छे पाये गये ।

बीज प्रौद्योगिकी

अपराजिता में 2 कि.ग्रा. तथा 4 कि.ग्रा. पोटेशियम नाइट्रेट के प्रयोग से बीज उपज, मानक उपज (355.91 कि.ग्रा./हे.) की तुलना में क्रमशः 453.76 तथा 508.44 कि.ग्रा. प्राप्त हुई। कॉपर सल्फेट के 1.0 कि.ग्रा./हे. के पर्ण छिड़काव से 492.56 कि.ग्रा./हे. बीज उपज प्राप्त हुई जबकि मानक उपचार से 420.07 कि.ग्रा. बीज उपज प्राप्त हुई।

नत्राजन की 80 कि.ग्रा. तथा 120 कि./हे. के प्रयोग से नन्दी घास की बीज उपज क्रमशः 27.53 कि. ग्रा. व 38.233 कि.ग्रा./हे. प्राप्त हुई।

ट्रिसोल (जिवरैलिक एसिड तथा एक पोषक पदार्थ का मिश्रण) के प्रयोग से बरसीम की बीज उपज में वृद्धि हुई है।

बीज दैहिकी, बीज परीक्षण एवं गुणवत्ता नियंत्रण

लोबिया की प्रजाति इगफ्री 450 (66 दिन), ई.सी. 4216 (70 दिन) तथा आई. एफ. सी. 901(83 दिन) की तुलना में शीघ्र पुष्पावस्था में आने वाली है तथा पुष्पावस्था के 20 दिनों के बाद इगफ्री 450 तथा ई.सी. 4216 पक जाती है।

ग्वार की बी.जी.–1 तथा बी.जी.– 2, किस्में 74 दिनों में तथा इगफ्री–1019, 79 दिनों में पुष्पावस्था में आती है।

स्टाइलो में तनु गन्धक के अम्ल के 1 मिनट प्रयोग तथा गर्म पानी (60°से.ग्रे.) के प्रयोग से अधिकाधिक अंकुरण सम्भव है। 100 पी.पी.एम. एन.ए.ए. + 2 कि. ग्रा./हे. डी.ए.पी. +4 कि./हे. पोटाश से उपज में वृद्धि सम्भव हुई है।

बीज स्वास्थ्य एवं भंडारण

प्लास्टिक केन/पॉलीथीन बैग (700 गेज) का उपयोग कीट/व्याधियों को रोकने के लिये सर्वोत्तम पाये गये हैं। और इस प्रकार 22 महीनों तक दलहनी बीजों का भंडारण करने पर प्रमाणीकरण हेतु पर्याप्त अंकुरण पाया गया । सिरिस तथा अपराजिता में इस प्रकार के भंडारण में वेबिस्टन और मैलाथियान (1:1)/1 ग्रा./कि.ग्रा. या क्रीरिजिलियम और अकोरस कैलामस/1 मि.ली./कि. ग्रा. बीज के प्रयोग से कीटों/भंडार में कबक, आदि से 22 महीनों तक मुक्ति सम्भव है।

पादप जन्य पदार्थ *क्रोटन टिडिलिया* (1.0 मि.ली. /कि.ग्रा.) बीज से दलहनी बीजों के भंडारण में जीवनाशी रसायनों के उपयोग को कम किया जा सकता है।

कृषि संयंत्र एवं कटनोत्तर तकनीकी

पैलेट के रूप में पशु आहार के लिये निर्मित यंत्र में सुधार हेतु छिद्र के आधार परिधि में रूपान्तरण किया गया। सतही द्वारकों को रोकने हेतु चारा संघनित यंत्र में मूलभूत सुधार किये गये।

आर्थिक विश्लेषण

ग्राम सकरार तथा आवास में चारा आधारित कृषि तंत्र पर अध्ययन से स्पष्ट हुआ है कि हाल के वर्षों में खाद्यान्न, नकदी तथा चारा फसलों के उत्पादन में वृद्धि हुई है।

कटाई तथा उठाई पद्धति में चारा उत्पादन में अधिकतम लागत (रू. 0.12 /कि.ग्रा.) तथा सतत् चराई पद्धति से न्यूनतम लागत (रु. 0.05/कि.ग्रा.) आती है। फिर भी अधिकतम चारा उत्पादन वाधित क्रमिक चराई पद्धति से सुनिश्चित हुआ। वाधित क्रमिक चराई पद्धति, चराई पद्धति, सतत् चराई पद्धति तथा कटाई एवं उठाई पद्धति से अधिक लाभ हुआ है।

तकनीक प्रसार

ग्राम करारी तथा लकारा में खरीफ में ज्वार तथा हरी घासों तथा ग्राम करारी और सुजाहा में रबी में मटर तथा चने की फसलों में उन्नतशील बैल चालित प्रक्षेत्रा यंत्रों का प्रदर्शन किया गया। इस उन्नतिशील तकनीक से पारम्परिक तरीकों के अपेक्षा 11–23 प्रतिशत का लाभ सुनिश्चित हुआ है।

प्रसार क्रियाकलापों में जैसे कृष्क प्रदर्शन क्षेत्रा में चारा उत्पादन तकनीक का प्रदर्शन, किसान मेला, किसान गोष्ठी, प्रदर्शनी, रेडियो/दूरदर्शन वार्ता नियमित रूप से किये गये। आठ प्रशिक्षण कार्यक्रमों का भी संचालन हुआ।

अविकानगर क्षेत्रीय केन्द्र

40 कि.ग्रा., फॉस्फोरस तथा वेम कवक द्वारा बरसीम तथा रिजका में वांछित स्तर में सुधार (20–30 प्रतिशत) सम्भव हुआ। वेम तथा राइजोवियम के साथ 40 कि. ग्रा. फॉस्फोरस के प्रयोग से 20–30 प्रतिशत वृद्धि सम्भव हुई है।

बुरादा के 20 कि.ग्रा. भूमि में बुवाई के पहले वेम कबक तथा राइजोवियम प्रयोग से लोबिया में जैव पदार्थ के 20 प्रतिशत अधिक मात्राा पाई गयी है।

लोबिया के निमेटोड प्रतिरोधी प्रजाति टी–152 में वेम तथा राइजोवियम के प्रयोग से 20 प्रतिशत अधिक उपज प्राप्त हुई।

धारवाड़ क्षेत्रीय केन्द्र

दीनानाथ घास + स्टाइलो के मिश्रण से अधिकतम चारा उत्पादन (24.07 टन/हे.) सम्भव हुआ है। जबकि ब्रेकेरिया + स्टाइलो, अंजन + स्टाइलो तथा अकेले स्टाइलो की फसल में कम उत्पादन हुआ है।

त्रिजातीय संकर बाजरा तथा अंजन घास को मेंड़ पर लगाने से अधिकतम चारा उपज (5.0 कि.ग्रा./4मीटर) सम्भव हुई है। जबकि घटते क्रम में त्रिजातीय संकर बाजरा + स्टाइलो (4.35 कि.ग्रा.), डी. एच. एन. 15 + स्टाइलो (4.20 कि.ग्रा.) और इगफ्री–3 + अंजन घास (3.35 कि.ग्रा) हुई है।

केन्द्र पर विकसित बाजरा प्रजातियों में डी.आर.एस. बी. 2 तीन वर्षों में सर्वोत्तम पायी गयी है।

बाजरा – नेपियर संकर डी.एच.एन.–2 नारियल बागानों में सर्वोत्तम पायी गयी।

क्लोरिस, बार्थोक्लोवा, नन्दी घास, केल घास, *डेसमेन्थस,* अपराजिया, स्टाइलो आदि में विभिन्न व्याधियों का अध्ययन किया गया।

Appendix I

Statement showing headwise expenditure during 1997-98

(Rs. in lakhs)

Head	Non-plan	Plan	Total
1. Pay and allowances	467.06	-	467.06
2. Wages	101.85	-	101.85
3. T.A.	4.30	2.50	6.80
4. Recurring contingencies	12.32	99.10	111.42
5. Non-recurring contingencies			
Works	-	7.25	7.25
Equipments	-	1.06	1.06
Vehicles	3.32	0.01	3.33
Others	-	1.57	1.57
Total	**588.85**	**111.50**	**702.35**