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annual report

1972

INDIAN GRASSLAND & FODDER RESEARCH INSTITUTE

JHANSI

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

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INDIAN GRASSLAND AND FODDER RESEARCH INSTITUTE

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CONTENTS

Progress of Research

INTRODUCTION

India has enormous livestock resources which, if efficiently exploited, can contribute effectively in solving the problem of protein hunger. Despite 343 million heads of livestock and 120 million poultry in the country, we are enormously short of animal proteins both quantitatively and qualitatively; the overall shortage in milk, meat and eggs is to the extent of about 51·0, 94·0 and 97·0 per cent, respectively. Besides other factors, one major reason for the low productivity and poor performance of our livestock is their malnutrition, under-nutrition or both. The productivity of the currently available major forage resources of the country consisting of crop residues, cultivated fodders and grasslands is grossly inadequate besides being generally deplete in quality and, as such, to meet the appropriate and immediate feeding requirements of all bovines in India, the production of concentrates, green fodder and dry fodder need to be increased by more than 6·0, 1·73 and 2·77 times the present level of production, respectively. Thus the provision of adequate quantities of quality fodders and feeds is an enormous task requiring a massive, purposeful and co-ordinated problems and production-oriented research programme involving multidisciplined approach.

The importance of grasses, grasslands and fodder crops in feeding the livestock and in the agricultural economy of the country, the increasing gap between the supply and demand of forage, the limitations of earlier studies and the diversity and complexity of the problems, led to the establishment of the Indian Grassland and Fodder Research Institute at Jhansi towards the end of the Third Five Year Plan by the Government of India and administered from April, 1966 by the Indian Council of Agricultural Research, New Delhi.

OBJECTIVES

The Institute has the following seven-fold major objectives :

1. To carry out research, both of basic and applied nature, on grasses, grasslands and fodder crops as related to

sustained production of high quality fodder for efficient animal production, maintenance of soil fertility and crop production.

2. To evolve high-yielding, fertilizer - responsive, disease and pest-resistant superior quality forage and fodder crops suited for different agro-climatic regions of the country by the use of modern techniques of plant breeding and through the application of research in other cognate disciplines.

3. To study all aspects of the problems of weeds in cultivated fodder and grasslands and evolve economic measures of their control.

4. To design and fabricate efficient, low cost, labour saving farm machinery and implements from indigenous materials to meet the diverse needs, with special reference to forage cultivation in small farm holdings.

5. To conduct basic and applied researches on all aspects of seed production in forage crops for evolving efficient seed production techniques as well as to devise suitable control measures for protecting seed under storage from diseases and pests.

6. To collect, co-ordinate and collate research work on the subject in the country by centralising direction/operation and superintendence.

7. To disseminate knowledge on the subject through organised training programme and conduct large scale forage demonstrations at national level

ORGANISATION

The Institute is currently organized into six technical divisions viz., (1) Plant Improvement, (2) Soil Science and Agronomy, (3) Grassland Management, (4) Plant Animal Relationship, (5) Weed Ecology and Control and (6) Extension and Economics (including Statistics) and

five sections, namely, Agricultural Engineering, Cartography, Seed Production, Farm and Library for successful implementation of the above objectives of the Institute through a comprehensive multidisciplined, problem-and production-oriented research programme.

The researches being carried on in these Divisions/Sections are directed to immediate problems following interdisciplinary approach in the fields of forage production and utilization. Thus, the primary objectives of researches undertaken in the Plant Improvement Division are to evolve superior (both in relation to quality and quantity and also other varied objectives specific for each crop) varieties of different forage crops suitable for cultivation under the different agroclimatic regions of the country through the use of modern techniques of plant breeding and the application of research in other cognate disciplines. Likewise, the research activities of the Division of Soil Science and Agronomy aim at obtaining maximum fodder production per unit area and per unit time through innovation and standardisation of suitable agronomic practices in the use of fertilizer application, soil-water management, cultural practices and micro-nutrient application both in respect of forage and seed production. Studies are also in progress to work out economic crop calendars for maximum year round forage production and studying the feasibility and economics of introducing forage crops in the existing cropping pattern. The research activities of the Grassland Management Division are geared to the uplift of our denuded grasslands to ensure their full potentiality of production by evolving a package of practices for their improvement, management and efficient utilization. The Plant Animal Relationship Division concerns with finding out ways and means for the achievement of enhanced and economical production of milk, meat and other animal products through the efficient utilization of various forage crops. The researches on all aspects of weeds and their control both in fields under cultivated fodders and grasslands are underway in the Division of Weed Ecology and Control. The Division of Extension and Economics is extending the research findings of the Institute to the cultivators and is also engaged in researches on economics of forage production besides helping the divisions in planning and layout of experiments, analysis and interpretation of data and carrying out statistical research.

In these research efforts, all the sections make valuable contributions. In addition, the Agricultural Engineering Section is also engaged in design, fabrication and development of farm machinery for use in fodder crops and in grassland farming. The unit of seed production, created in the Fourth Plan is devoted to the basic and applied researches relating to genetical, agronomical, physiological, pathological, entomological and technological aspects of forage seed production and storage.

ALL INDIA CO-ORDINATED PROJECTS

The Institute acts as the centre for direction, operation and/or superintendence of two major All-India Projects in the fields of forage production and utilization and economics of milk production and also houses some other All-India Co-ordinated Research Programmes. The former project has eight main centres and six sub-centres and the latter has nine centres located in different parts of the country. The co-ordinating units and the two project Co-ordinators for these Projects are located at this Institute. The Institute also participates in the National Demonstration Scheme of the I. C. A. R. in which it conducts demonstration on forage crops in the farmer's fields all over the country adopting improved package of agronomic practices standardized for maximising yield in improved varieties. A sub-centre of the All-India Scheme on Dryland Agricultural Farming is also located at this Institute. Under this, trials are being conducted using fodder crops under different soil conditions with rain water during *Kharif* and also on conserved moisture during *rabi*. A unit of another All-India Scheme, viz., Co-ordinated Agronomic Experiments of the I. C. A. R., functioning at this Institute, is devoted to study the nutrient response of various crops under different soil tracts. A sub-centre of the All-India Co-ordinated Project on fodder and grain *Sorghums* is also located at this Institute,

STAFF PATTERN

The Director is the technical and administrative head of the Institute. The main Institute including the units of the different schemes functioning in the Institute has a sanctioned strength of 174 scientific and

specialised personnel, 23 technical staff, 69 administrative and 72 supporting and watch and ward staff. Of this about 40 per cent of the posts are remaining vacant. Several senior scientists have already joined the Institute to man the various laboratories and the remaining, about 40 per cent of the positions, which are still vacant are in the process of being filled up on an All-India competition basis. During the year under report, the staff position in the various Divisions/ Sections/Schemes is summarised below upto Research Assistant level as on 31.12.1972.

Designation	*Name*	*Date of joining*
Director	Dr. M. L. Magoon	10.6.1970
Junior Scientific Officer	Vacant	
P. A. to Director	Sri O. P. Dubey	25.1.1971

PLANT IMPROVEMENT DIVISION

Head of Division	Dr. K. L. Mehra	15.4.1967
Botanist	Vacant	
Plant Breeder (Legumes)	Sri Amar Singh	15.5.1969
Cytogeneticist	Vacant	
Plant Breeder (Grasses)	Dr. R. Krishnan	12.10.1970
Geneticist (Grasses)	Vacant	
Geneticist (Legumes)	Vacant	
Junior Plant Pathologist	Dr. S. T. Ahmad	6.2.1970
Junior Breeder (Grasses)	Vacant	
Junior Entomologist	Sri Shri Ram	4.5.1970
Junior Breeder (Legumes)	Vacant	
Junior Plant Physiologist	Dr. R. B. R. Yadav	28.8.1972
Junior Cytogeneticist	Vacant	
Junior Botanist	Vacant	
Asstt. Plant Improvement Officer (Legumes)	Sri C. B. Singh	11.7.1968
Asstt. Plant Improvement Officer (Grasses)	Sri Bhag Mal	15.7.1968
Senior Research Assistant	Sri M. S. Yadav	22.2.1969
Senior Research Assistant	Sri K. S. Kohli	.5.1972

Senior Research Assistant	Vacant	
Senior Research Assistant	Vacant	
Senior Research Assistant	Vacant	
Research Assistant	Sri Devendra Singh	1.1.1968
Research Assistant	Sri K. S. Kohli	4.1.1968 (upto 8.5.1972)
Research Assistant	Sri K. C. Velayudhan	18.8.1969 (upto 9.5.1972)
Research Assistant	Vacant	

SOIL SCIENCE AND AGRONOMY DIVISION

Head of Division	Vacant	
Fodder Agronomist (Crop Husbandry)	Dr. M. N. Mishra	30.9.1967 (upto 9.10.1972)
Agronomist (Soil and Water Management)	Dr. S. B. Hukkeri	5.4.1968 (upto 4.5.1972)
Agronomist (Dryland)	Vacant	
Soil Scientist	Dr. N. D. Mannikar	1.9.1969
Junior Agronomist (Drainage)	Vacant	
Assistant Agronomist (S.W.M.)	Sri N. P. Shukla	5.8.1972
Assistant Soil Scientist	Dr. Dashrath Singh	7.9.1972
Assistant Agronomist (Crop Husbandry)	Vacant	
Senior Research Assistant	Sri S. N. Tripathi	5.8.1972
Senior Research Assistant	Vacant	
Senior Research Assistant	Vacant	
Senior Research Assistant	Vacant	
Research Assistant	Sri Gopi Chandra	5.1.1968 (upto 4.5.1972)
Research Assistant	Sri N. P. Shukla	15.1.1968 (upto 4.8.1972)
Research Assistant	Sri S. N. Tripathi	8.9.1969 (upto 4.8.1972)
Research Assistant	Vacant	

GRASSLAND MANAGEMENT DIVISION

Head of Division	Sri P. M. Dabadghao	1.11.1962 (upto 9.10.1972)
Ecologist	Dr. K. A. Shankarnarayan	3.1.1964

Ecologist (Grassland Management)	Sri K. C. Kanodia	22.9.1957
Ecologist (Forest Grazing)	Sri R. Debroy	5.5.1970
Assistant Ecologist	Dr. Vinod Shankar	31.7.1967
Assistant Ecologist	Dr. P. S. Pathak	24.12.1969
Assistant Ecologist	Dr. P. K. Jayan	25.2.1971
Senior Research Assistant	Sri K. C. Velayudhan	10.5.1972
Senior Research Assistant	Vacant	
Senior Research Assistant	Vacant	
Research Assistant	Sri V. S. Upadhyay	15.1.1968 (upto 20.2.1972)
Research Assistant	Sri B, K. Trivedi	11.8.1969
Research Assistant	Sri Ravi Kumar	22.9.1969

WEED ECOLOGY AND CONTROL DIVISION

Head of Division	Dr. T. R. Dutta	13,12.1967
Agronomist (Weed Control)	Dr. R. P. Singh	6.11.1967
Organic Chemist	Dr. R. K. Gupta	31.5,1969
Assistant Agronomist	Shri R. K. Pandey	28.5.1968
Assistant Chemist	Sri A. K. Srivastava	24.12.1969 (upto 7.11.1972)
Asstt. Systematic Botanist	Dr. S. R. Gupta	21.1.1970
Asstt. Plant Physiologist	Dr. R. B. R. Yadav	6.7.1972 (upto 27.8.1972)
Senior Research Assistant	Sri O. P. S. Panwar	27.11.1969
Senior Research Assistant	Vacant	
Senior Research Assistant	Vacant	
Senior Research Assistant	Vacant	
Research Assistant	Sri J. N. Gupta	18.9.1969
Research Assistant	Vacant	
Research Assistant	Vacant	

PLANT ANIMAL RELATIONSHIP DIVISION

Head of Division	Dr. A. Rekib	10.4.1972
Livestock Specialist	Dr. A. Rekib	14.4.1969 (upto 9.4.1972)
Animal Nutritionist	Vacant	

Analytical Chemist (Trace Elements)	Vacant	
Junior Analytical Chemist	Sri S. C. Gupta	2.11.1970 (A/N)
Junior Animal Nutritionist	Vacant	
Junior Chemist (Bio-assay)	Vacant	
Junior Instrumentalist	Vacant	
Veterinary Officer	Sri J. Prasad	17.3.1972
Asstt. Analytical Chemist	Vacant	
Asstt. Livestock Officer	Vacant	
Asstt. Livestock Officer	Sri V. S. Upadhyay	21.2.1972
Assistant Biochemist	Sri A. P. Singh	9.5.1972
Senior Research Assistant	Sri A. P. Singh	22.2.1969 (upto 8.5.1972)
Senior Research Assistant	Vacant	
Senior Research Assistant	Vacant	
Senior Research Assistant	Vacant	
Senior Research Assistant	Vacant	
Research Assistant	Sri N. C. Verma	10.1.1961
Research Assistant	Vacant	(upto 8.5.1972)
Research Assistant	Vacant	
Research Assistant	Vacant	
Livestock Assistant	Sri A. K. Dabadghao	18.11.1969

EXTENSION AND ECONOMICS DIVISION

Senior Agronomist(Extension)	Vacant	
Statistician	Sri P. R. Sreenath	8.5.1968
Extension Agronomist	Vacant	
Junior Statistician	Vacant	
Jr. Agronomist(Demonstration)	Vacant	
Asstt. Agricultural Economist	Sri H. H. Datta	18.1.1968
Photographer-cum-Artist	Vacant	
Sr. Statistical Investigator	Vacant	
Sr. Technical Assistant	Vacant	
Sr. Research Asstt.(Extension)	Vacant	
Sr. Research Asstt.(Extension)	Vacant	
Sr. Research Asstt.(Economics)	Vacant	

Research Asstt.(Economics)	Sri Ram Prakash	4.11.1969

FARM SECTION

Farm Manager	Vacant	
Farm Superintendent	Sri S. P. Marwaha	15.2 1967
Farm Assistant	Vacant	
Farm Assistant	Vacant	

AGRICULTURAL ENGINEERING SECTION

Senior Research Engineer	Vacant	
Agricultural Engineer	Sri Jai Singh	16.12.1969
Asstt. Agricultural Engineer	Sri R. B. Varshney	2.6.1972
Land Surveyor	Sri H. B. Dhingra	11.10.1971
Senior Research Assistant	Vacant	
Senior Research Assistant	Vacant	

CARTOGRAPHY SECTION

Junior Cartographer	Sri S. Pandey	4.5.1971 (upto 30.9.1972)

SEED PRODUCTION SECTION

Seed Production Officer	Vacant
Geneticist (Seed Production)	Vacant
Seed Physiologist	Vacant
Plant Pathologist	Vacant
Entomologist	Vacant
Senior Research Assistant	Vacant
Senior Research Assistant	Vacant
Senior Research Assistant	Vacant

ADMINISTATIVE UNIT

Administrative Officer	Sri A. S. Bhati	25.2.1970 to 21.8.1972
Administrative Officer	Sri H. C. Tewari	22.8.1972
Office Superintedent	Shi A. S. Bhati	3.11.1966 and 22.8.1972

Head Clerk	Sri H. C. Saxena	3.12.1969
Estate Officer	Vacant	

ACCOUNTS UNIT

Senior Accounts Officer	Vacant	
Accounts Officer	Sri R. C. Saxena	3.6.1969
Junior Accountant	Sri J. N. Parashar	16.3.1971
Junior Accountant	Vacant	
Junior Accountant	Vacant	

STORES UNIT

Store Officer	Sri A. Krishna	21.8.1972

LIBRARY SECTION

Assistant Librarian	Vacant	
Senior Library Assistant	Sri M. M. Rastogi	1.5.1967

MEDICAL UNIT

Junior Medical Officer	Vacant	

ALL INDIA CO-ORDINATED PROJECT ON FORAGE CROPS

Project Co-ordinator	Dr. B. D. Patil	9.8.1971
Junior Statistician	Sri J. A. Sastry	28.6.1972
Senior Research Assistant	Sri O. P. Dixit	9.5.1972

ALL-INDIA CO-ORDINATED PROJECT ON ECONOMICS OF MILK PRODUCTION

Co-ordinating Unit		
Project Co-ordinator	Vacant	
Junior Statistician	Sri D. P. Handa	10.11.1972
Research Unit		
Junior Agronomist	Sri J. T. Karnani	24.2.1972
Veterinary Officer	Vacant	
Senior Research Assistant	Sri N. C. Verma	9.5.1972

ALL INDIA CO-ORDINATED AGRONOMIC EXPERIMENT

Junior Agronomist	Sri. D. N. Singh	4.10.1972

ALL-INDIA CO-ORDINATED PROJECT ON DRYLAND AGRICULTRE

Agronomist	Vacant	
Junior Engineer	Sri J. P. Saxena	2.5.1972
Jonior Soil Physicist	Dr. C. R. Hazra	5.7.1972
Senior Research Assistant	Sri Gopi Chandra	1.9.1971 (upto 29.2.1972)
Senior Research Assistant	Sri M. D. Singh	14.8.1972
Senior Research Assistant	Vacant	
Senior Research Assistant	Vacant	

ALL-INDIA CO-ORDINATED PROJECT ON SORGHUM

Junior Agronomist	Sri A. S. Gill	12.5.1972
Junior Breeder	Vacant	
Research Assistant	Vacant	
Research Assistant	Vacant	

SUB-STATION AT MANASBAL (SRINAGAR, J & K)

Agrostologist	Vacant
Senior Research Assistant	Vacant

FACILITIES

(a) *Experimental Farm* : The institute has about 575 hectares of experimental farm situated at a distance of about 8 km from the town of Jhansi on the Jhansi-Gwalior road. The farm is located in the transitional zone with contrasting soil types and varying topography. About 356 hectares are under natural grasslands and about 135 hectares have been brought under cultivated fodders adopting suitable soil reclamation and conservation measures. The farm has a good potential for irrigation and supplementary source for irrigation water. There is also a well-equipped meteorological observatory, located in the centre

of farm to provide data on weather conditions. It also has an adequate farm building. The strength of livestock is also being progessively enlarged to meet the research requirements.

(b) *Laboratories and buildings* : The Institute moved into its own buildings near Pahuj Dam on Jhansi-Gwalior Road in the month of July, 1972. Only the Administrative block and one wing of the Laboratory blocks were taken over from the C. P. W. D. and all the staff was accommodated in these buildings. The modern and sophisticated equipment purchased and received under U. N. D. P. (S. F.) have been housed in special equipment rooms with provisions for Air-conditioning. The spacious laboratories with modern equipment and upto-date facilities are being fully utilized for undertaking comprehensive and integrated researches on diverse aspects of forage production and utilisation. The matter relating to the construction of Glass house with facilities for controlled conditions of temperature, humidity and light has reached the advanced stage for issue of notice inviting tenders.

Following the completion of construction work of 61 residential quarters of different types, the quarters taken over from the C.P.W.D. have been allotted to the staff of the Institute. The remaining quarters are likely to be taken over shortly.

(c) *Library* : Library further procured 215 technical books, 90 foreign scientific journals and 54 Indian scientific periodicals during the year thus bringing their totals to 2420 technical books and 400 periodicals in the library for use of the scientists. Besides, the library has also been strengthened by the addition of many reprints of scientific papers and technical publications of various types from different research institution within the country and abroad. A new efficient system of issuing of books to borrowers has been introduced to facilitate wide scale use of library.

(d) *Museum* : The museum of the Institute was reorganised by including more informative aud instructive maps, charts, diagrams and photographs depicting the research activities and achievements of the Institute. The live specimens and new farm implements have also been kept in the museum for the benefit of farmers.

(e) *Advanced Training of the staff*: Dr. K. A. Shankarnarayan underwent specialised training in Grazing Ecology using sheep fitted with Oesophageal fistula at the Grassland Research Institute, Hurley, U. K. from May to August, 1972 under U. N. D. P. (F. A. O.) fellowship programme. This was followed by training in Fodder Pruduction and Conservation at the Research Centre of Agriculture, Braunschweig, Volkenrode, West Germany during September, 1972,

Shri R. K. Pandey, Assistant Agronomist (Weed Control) received advanced training in the field of weed control under the Colombo Plan for the period from January to July at Weed Research Organisation, Begbroke Hill, Oxford, U. K.

RESEARCH COLLABORATION AT NATIONAL LEVEL

Besides actively serving the six All-India Co-ordinated schemes referred to already, the Institute developed effective collaboration with the Institute of Agricultural Research Statistics, New Delhi, Indian Agricultural Research Institute, New Delhi; National Dairy Research Institute, Karnal; Indian Veterinary Research Institute, Izatnagar; Central Arid Zone Research Institute, Jodhpur; Central Sheep and Wool Research Institute, Malpura; Punjab Agricultural University, Ludhiana, Haryana Agricultural University, Hissar; Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur and several research stations of the U, P.State in the conduct of trials on forage crops and for exchange of herbage materials.

RESEARCH COLLABORATION AT INTERNATIONAL LEVEL

The United Nations Development Project on grassland and forage development in India (IND-42) which has been in operation at this Institute since September, 1969 continued to implement successfully the approved techical programme and under this project the Institute also received assistance by way of expertise, equipments fellowships for overseas training of the counterpart personnel.

EXTENSION AND EDUCATION

(a) *Advisory services* : The facilities developed at the Instithte were fully utilized in maintaining liaison between the cultivators, extension workers and research workers and rendering advisory service

to interested agriculturists. Information on matters of technical and general nature on different aspects of cultivation of grasses and fodder crops was given to various parties which included farmers, private individuals, Block Development Officers, Students, State/Central Governments, Universities, Colleges and Research Institutes. The necessary advice was also provided to farmers and cultivators by visiting the defferent areas during the defferent phases of crop growth.

(b) *Technical publication an Talks* : Apart from giving invited lectures on various aspects of forage cultivation and utilization in the Agricultural Colleges, research Institutions and also through All-India Radio for the benefit of the interested growers/agricultural graduates, post-graduate students and research workers, 33 research papers and articles of general interest were written up for publication in different appropriate journals/presntation at different All-India Seminars/ Conferences etc. to disseminate the results of research.

(c) *Seed supply* : In response to requests from several State/ Central agencies and private organisations, varying quantities of seeds of forage crops were supplied during the year.

(d) *National Demonstration* : During the year 1972, the Institute conducted six National Demonstration trials in Uttar Pradesh with the active support of the State Government and the State Co-or dination Committee on Grassland and Fodder Development in U. P. Out of six demonstrations, four were of two crop rotations and the remaining two trials were of one crop rotation. The crop rotations were so selected that one or both the crops were of fodder as approved in the earlier workshops. The results have shown that the growing of fodder crops in a single year either in two crop rotation or in one crop rotation is more economical and the targets fixed (60 tons of green fodder/ha/year) were well achieved.

(e) *Training :* A training course was organised at the Institute in collaboration with the Directorate of Extension, Ministry of agriculture, New Delhi for 10 days from 18th to 27th September, 1972 for imparting knowledge on the advanced technology in fodder production and its

efficient utilisation to the senior animal husbandry officers of the various States. The State Governments responded well by sponsoring senior fodder development officers, veterinary officers and/or agricultural officers. In all fifteen senior officers from 11 states participated in the training course.

The traning course, *inter alia* covered wide aspects of fodder production and utilization under 10 sections, namely, plant improvement, fodder agronomy, grassland management, fodder conservation, nutritional evaluation, weed control, agricultural machinery, agricultural economics, cartography and techniques of experimentation.

The Fodder Development Officer Trainees were also taken on field trips to Gwalior (Gwalior Dairy Limited) and Agra (Military Farm and adjoining areas) on 24th September, 1972 to acquaint them on the various aspects of fodder and milk production on a commercial scale and to familiarise themselves on management of dairy herd maintained mostly on the fodder grown in the farm.

WORKSHOPS/CONFERENCES/SYMPOSIA

The Scientific/technical staff of the Institute attended the following Workshops/Conferences/Symposia during the year 1972.

1. 2nd All-India Workshop on Economics of Milk Production held at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur on 18th and 19th December, 1972.
2. 25th Annual Conference of the Indian Society of Agricultural Statistics held at Institute of Agricultural Research Statistics, New Delhi.
3. Symposium on Multiple Cropping held at Haryana Agricultural University, Hissar.
4. Workshop on National Demonstrations held at Indian Agricultural Research Institute, New Delhi.
5. Refresher Training Programme for officers working under All-India Co-ordinated Agronomic Experiments held at Indian Agricultural Research Institute. New Delhi during 18th to 23rd march, 1972.

6. Indo-Soviet Symposium on "Gene pools, centres of origin of crop plants and recent advances in Mutation Research" jointly organised by Indian National Science Academy and the Academy of Science of U S S R at National Academy of Sciences building, New Delhi from 10th to 13th November, 1972.
7. 3rd Workshop on All-India Coordinated Research Project for Dryland Agriculture held at Hyderabad from 4th to 8th February, 1972.
8. Rabi Worker's Conference on All India Coordinated Research Project for Dryland Agriculture held at Indian Agricultural Research Institute, New Delhi from 22nd to 24th September, 1972.

FINANCE

The Institute is provided with an adequate budget in proportion to its current stage of development. The actual expenditure incurred from January to December, 1972 is as follows :

		Revenue Expenditure	Capital Expenditure	Total
Plan	Rs.	14,12,064.95	3,00,000.00	17,12,064.95
Non-Plan	Rs.	1,88,195.40	—	1,88,195.40
Total	Rs.	16.00,260.35	3,00,000.00	19,00,260.35

After meeting the feed and fodder requirements of the livestock strength at our farm, the total receipts from the sale of farm produce amounted to Rs. 1,66,809.12.

VISITORS

During the period under report, the Institute had the benefit of visits by eminent scientists, important dignitaries and distinguished persons. In addtton, various groups of students, farmers, block development officers, extension workers and others visited the laboratories and Farm of the Institute. Some of the distinguished visitors are listed below :

1. Shri Ram Lakhan,
   Minister for Agriculture and Animal Husbandry,
   U. P. State, Lucknow.
2. Shri K. C. Sharma,
   Deputy Minister for Planning and General Administration,
   U. P, State, Lucknow.

3. Dr. B. K. Soni,
Deputy Director General (AS),
Indian Council of Agricultural
Research,
New Delhi.

4. Shri Biharilal Vashit,
Member of Legislative Council,
Jhansi.

5. Dr. J. Sybenga,
Professor of Genetics,
International Agricultural
University,
Wageningen, Holland

6. Dr, W. L. Pelton,
Canadian Joint Co-ordinator,
Dryland Agriculture Project,
Hyderabad.

7. Dr. G. Friesen,
Canadian Expert (Weed Control)
Dryland Agriculture Project
Hyderabad.

8. Mr. D. T. Anderson,
Canadian Expert (Engineering),
Dryland Agriculture Project,
Hyderabad.

9. Mr. R. I. Luney,
Canadian Expert
(Farm Machinery),
Dryland Agriculture Project,
Hyderabad.

10. Dr. S. L. Chowdhry,
Project Coordinator (DF),
All-India Co-ordinated Research
Project for Dryland Agriculture
Rajendranagar, Hyderabad.

11. Mr. G. H. W. Hutton,
Senior Agricultural Advisor/FAO
Country Rapresentative,
United Nations Development
Programme,
21, Kasturba Gandhi Marg,
New Delhi-1.

12. Mr. Michael Heyn,
Assistant Resident
Representative,
U. N. D. P., New Delhi.

13. Mr. E R. Syned,
Acting Project Manager,
Sheep and Wool Development,
U.N.D.P., New Delhi.

14. Mr. P. Andersen,
Danish Director,
Indo-Danish Cattle Breeding
Project,
Hassarghatta, Banglore.

15. Mr. R. N. Azaad,
Special Secretary (Agriculture),
U. P. State, Lucknow,

16. Mr R. Kuenzi, Project Advisor,
U. N. D. P., New Delhi.

17. Dr. A, N Ghosh,
Deputy Commissioner,
Govt. of India,
Ministry of Agriculture
(Department of Agriculture),
New Delhi.

18. Dr. V. R. Bhalerao,
Assistant Director General
(Dairying)
I. C. A. R., New Delhi.

19. Shri S. G. B. Mullick,
Secretary (Home)
Govt. of U. P., Lucknow.

20. Shri S. V. S. Juneja,
Secretary (Finance)
Govt. of U. P., Lucknow.

21. Shri Ram Krishna,
Director of Agriculture,
Govt. of U. P., Lucknow.

22. Dr. N. D. Arora,
Professor and Head,
Department of Plant Breeding,
Haryana Agricultural University,
Hissar.

23. Prof. R. N. Srivastava,
Allahabad Agricultural
Institute,
Allahabad (U. P.)

24. Shri P. S. M. Ifrahim,
Commissioner,
Jhansi.

25. Shri M. P. Jain, City Magistrate,
Jhansi.

26. Mr. Dua,
Administrative Officer,
U. N. D. P., New Delhi.

27. Dr. R. S. Mathur,
Retired Scientist (ICAR)

28. Dr. Shahazada Singh,
Deputy Director of Agriculture,
Soil Conservation, Mirzapur.

29. Deputy Director of Agriculture.
Soil Conservation,
Allahabad.

30. Shri M. Z. Hussain,
Project Executive Officer,
Etawah.

31. Shri V. N. S. Shisodia,
Jonior Associate
(Soil Conservation),
Etawah.

32. Prof. A. Sen,
Division of Microbiology,
Indian Agricultural Research
Institute, New Delhi.

33. Dr. S. B. Hukkeri,
Senior Agronomist,
I. A. R. I., New Delhi.

34. Prof. L.L. Relwani,
National Dairy Rescarch
Institute, Karnal.

35. Shri H. N. Mathur,
Soil Conservation Research
Demonstration and Training
Centre, Dehradun.

36. Shri Bhupan Singh,
Lecturer in Agronomy,
Ranchi Agricultural College,
Kanke, Ranchi.

37. Shri M. Laxinarayana,
Senior Assistant Director,
Composits Livestock Farm and
Research Station,
Hessarghatta, Mysore State.

38. Shri G. G. Nanjangud,
Superintendent,
Large Scale Sheep Breeding
Farm,
Challakere, Mysore State.

39. Shri V. D. Mangrulkar,
Fodder Development Officer,
Poona, Maharashtra State.

40. Shri S. B. Tringare,
Fodder Development Officer,
Intensive Cattle Development Project,
Dhulia, Maharashtra State.

41. Shri P. N. Mathur.
Fodder and Grassland Development Officer,
Jaipur, Rajasthan State.

42. Dr. T. Zeliang
Key Village Officer,
Kohima, Nagaland.

43. M. C. Jyrwa.
Shillong, Meghalaya.

44. Shri A. A. Shah,
Agricultural Officer,
Large Scale Sheep Breeding Farm,
Mamidipally, Andhra Pradesh.

45. Shri G. Bhimreddy,
Seed and Fodder Development Officer,
Hydrabad, Andhra Pradesh.

46. Shri S. C. Roy,
Assistant Director
(Animal Husbandry),
Agartala, Tripura.

47. Shri G. C. Goel,
Veterinary Assistant Surgeon,
Himachal Pradesh, Simla.

48. Shri K. V. Bondale,
Fodder Agronomist,
Ankleshwar, Gujarat State.

49. Shri M. M. Mehta,
Fodder Development Officer,
Intensive Cattle Development Project,
Mehsana, Gujarat.

50. Shri J. F. Patel,
Fodder Development Officer,
Ahmedabad, Gujarat.

51. Shri M. S. Tyagi,
Lecturer (Fodder),
Chak. Gajaria Farm,
Lucknow, U. P.

52. A batch of Students from
Lucknow, Polytechnic,
Lucknow.

53. A batch of trainees from
Gazaria Farm.

54. A batch of students from
Almora.

55. A batch of Students
from Soil Conservation and
Training Centre,
Muzfarabad, Saharanpur.

56. A batch of students from
Allahabad Agricultural Institute,
Allahabad.

57. A batch of in-service trainees
from Chak. Gajaria, Lucknow.

58. A team of soil conservation
officers from Mirzapur.

59. A team of Soil Conservation
Staff, Muzafarabad, Saharanpur.

60. A team of Officers from
State Soil Conservation
Training Centre, Mauranipur.

61. A Batch of Students from the
College of Agriculture,
A.P. Agricultural University,
Rajeadranagar, Hyderabad.

62. A batch of Soil Conservation Officers from Allahabad.

63. A batch of students from Ranchi Agricultural College, Kanke, Ranchi.

HONOURS AND AWARDS

Dr. M. L. Magoon continued to function as President of the International Society for Root and Tuber Crops following his unanimous election made by the 2nd International Symposium on Tropical Root and Tuber crops held at University of Hawaii, Honolulu, Hawaii, U. S. A.

On the invitation of the Centro International de Agriculture Tropical (CIAT), the International Development Research Centre (IDRC) and the Canadian International Development Agency (CIDA) Dr. M. L. Magoon. Director participated in the Cassava programme review conference held from 10th to 12th January, 1972 at Cali, Columbia as the representative of Government of India. The Conference *inter alia* reviewed the current status of Cassava Production and the related problems for its improvement in the various countries and to draw up, on global scale, problem and production oriented research involving close collaboration of participant countries.

WEATHER CONDITIONS AND CROPS PROSPECTS

The year 1972 was comparatively a dry year. The total annual rainfall was 743 mm which was 21 per cent less than the average rainfall of 936 mm per annum. The number of rainy days was 31 as compared to the average of 46 days per year. The rainfall distribution pattern during the year under report was also very erratic. The period from January to May received no rains. The entire rainfall was received during the period starting from 30th June to 16th September. Even so, there was a dry spell for 16 days commencing from 18th July, adversely affecting the crop establishment and growth. August was the wettest month and received 510 mm rainfall (69 per cent of total) in 15 rainy days. After 16th September, the season was dry and the crops further suffered due to lack of moisture in the soil, especially where supplementary irrigation could not be made available. Rabi crops were otherwise

normal as no climatological hazards (hailstorm or frost) occurred during this period.

Weekly mean maximum temperature for the year ranged from 22.0 to 45.0°C and minimum temperature from 2.5 to 29.9°C. The maximum temperature of 46.9°C was recorded on 16th June and the minimum of 0.6°C on 9th January.

The relative humidity was lower upto the third week of June and thereafter the whole monsoon period was humid. The weekly average evaporation from Std. U. S. open pan evaporimeter ranged from 2.0 (3rd week of January) to 20.7 mm (3rd week of June) per day.

PROGRESS OF RESEARCH

The Institute pursued its various research projects relating to forage production and utilization as programmed by the Staff Research Council of the Institute and also approved by Indian Council of Agricultural Research, in proportion to the facilities built-up and staff strength available. The technical programme for the year 1972 alongwith salient features of research and their details are presented below.

TECHNICAL PROGRAMME 1972

Plant Improvement Division :

PI–1 Introduction and evalution of forage legumes and grasses.
- 1.1 Introduction and evaluation of range grasses.
- 1.2 Introduction and evaluation of range legumes.
- 1.3 Introduction and evaluation of cultivated legumes.

PI–2 Production and quality breeding in fodder grasses.
- 2.1 Production and quality breeding in fodder sorghum and oats.

PI–4 Production and quality breeding in cultivated fodder legumes.
- 4.1 Breeding varieties for high fodder yield and quality in cowpeas.
- 4.2 Variety synthesis for high fodder and quality in iucerne.
- 4.3 Variety construction for high yield and quality in Velvet bean.

PI–5 Production and quality breeding in pasture legumes.
- 5.1 Variety construction for high yield, quality and cold tolerance in carpet legume.

PI–6 Plant Pathological investigations on forage crops.
- 6.1 Prevalance and distribution of plant diseases.
- 6.2 Host-parasite relationships.

6.3 Effect of plant diseases on yield, quality and physiology of forage crops.

6.4 Standardization of control measures.

PI–7 Entomological investigations on forage crops.

7.1 Evaluation of losses in green fodder yield due to damage caused by major insect pests of cowpeas and lucerne.

7.2 Relative efficacy of common and safer pesticides in the control of pests of cowpea, lucerne and sorghum.

Soil Science and Agronomy Division :

SA–1 Evaluation of genotypic response of fodder crops.

(a) Strains of tetraploid berseem.

(b) Oat varieties and response to N. & P.

SA–2 Cultural management and fertilizer use in fodder crops.

(a) Late application of nitrogen in oats.

(b) Top dressing of N to soil, foliar application of spray grade and fertilizer grade urea in oats.

(c) Seed rates of M. P. chari.

(d) N application in M. P. chari under rainfed conditions.

(e) Top dressing of N in teosinte.

(f) Top dressing of N to soil, foliar application of spray grade and fertilizer grade urea and pre-emergence soil application of simazine in M. P. chari.

(g) Spray grade *vs* fertilizer grade urea in teosinte.

(h) *Sarson* varieties for mixed sowing with berseem.

(i) N fertilization and cutting management in M. P. chari and Sudan grass.

(j) P & K response in lucrene.

(k) Spacing-cum-manurial trial in guinea grass.

SA–3 Cropping patterns for maximum fodder production.

(a) For year round fodder production.

(b) Growing fodder crops in the gap period of two grain crops.

(c) Maximum production potential trial.

SA–4 Seed Production in fodder crops.
- (a) Cycocel (CCC) spray in oats.
- (b) Ascorbic acid spray in berseem.
- (c) Micronutrient spary in berseem.

SA–5 Soil-water managment of fodder crops.
- (a) Water use efficiency in year round fodder production.
- (b) Irrigation, N, P and K requirements of turnip.
- (c) Hybrid napier under varying plant density and N fertilization.
- (d) Soil moisture stress on M. P. chari.
- (e) Soil moisture stress on berseem seed production.
- (f) Soil moisture stress on oat seed production.

SA–6 Availability and uptake of nutrients.
- (a) Sulphur nutrition to berseem.

Grassland Management Division :

GM–1 Grassland productivity.

1.1 Primary productivity, energetics and nutrient circulation in grasslands.

1 2.1 Effect of nitrogen and phosphorus on production and quality of principal grass communities of *Sehima Dichanthium* grasslands.
- (a) *Heteropogon contortus.*
- (b) *Sehima nervosum.*

1.2.3 Effect of nitrogen and phosphorus on the production and quality of herbage in *Cenchrus Setigerus.*

1.2.4 Effect of nitrogen and phosphorus on the production and quality in *Cenchrus ciliars.*

1.4.1 Effect of the application of varying doses of phosphate and varying intervals of cutting on the growth and forage production of tropical pasture legumes.

GM–2 Grassland improvement.

2.1 Suitable technique for the establishment of promising legumes in natural grasslands.

GM–3 Grassland utilization.

3.1 Ralative grazing values of principal species of *Sehima-Dichanthium* cover.

GM–4 Range ecology.

4.3 Study of plant succession in *Sehima-Dichanthium* grasslands.

4.3.1 Study of moisture regime in grassland soils and its effect on the growth and yield of grasses.

(a) *Sehima nervosum.*

(b) *Heteropogon contortus.*

4.4 Autecology of grassland species.

1. Germination studies.

4.5.1 Effect of frequency of burning with or without grazing on changes in the botanical composition in *Sehima* grasslands.

GM–5 Forest grazing, appraisal, production and utilization.

5.1 Evaluation of forest grazing resources of dry deciduous forest grasslands.

5.2 Silvipastoral studies on fodder trees.

Weed Ecology and Control Division :

WE–1 Survey and collection of weeds.

1.1 Autecogy of weeds.

1.2 Regional weed survey, collection and mapping.

1.3 Studies on crop-weed interactions.

WE–2 Structure–activity relationship and selectivity of herbicides.

WE–3 Weed control as an input for higher productivity in fodder crop rotations.

WE–4 Fate of herbicides in plants and their interactions.

WE–5 Evaluation of herbicide toxicity on animals.

WE–6 Nutrients availability and uptake as affected by herbicides application.

Plant Animal Relationship Division :

PAR–1 Evaluation of forage crops in relation to livestock production.

1.1 Studies on the chemical evaluation of forage crops for nutrient yield, possible phyto-toxic and other physiologically active constituents.

1.2 *In vitro* studies on the digestibility of important fodders and forage crops.

1.3 Studies on the nutritive value of important fodders and forage crops for buffalo cattle and goat.

PAR–2 Studies on the economical use of fodder for increased livestock production.

2.1 Studies on the production potential of different forages in terms of quantity and quality of goat meat.

2.2 Studies on the effect of feeding fodder–based ration on the growth rate, sexual maturity and first lactation yield of buffalo heifers.

2.3 Studies on the economics of milk production under different farming conditions.

PAR–3 Studies on the conservation of fodders and forage crops.

3.1 Conservation of green forages into quality hay, silage.

PRA–4 Studies on the metabolism of farm animals by feeding fodders and forage crops.

4.1 Studies on the effect of feeding important fodders and forage crops on rumen metabolism and efficiency of milk production.

4.2 Studies on the effect of seasonal variation on efficiency of energy utilization by animal of forage based ration.

4.3 Studies on the rumen metabolism and possible microbial changes in rumen by feeding different levels of herbicides/ herbicide treated fodders and forage crops.

Extension and Economics Division :

AES–1 Study on year to year cost of cultivation of general crops (Kharif and Rabi) in the Central Research Farm.

AES–3 Studies on the Economics of milk production.

AES–4 Allied studies in the Central Research Farm.

(a) Bullock maintenance cost.
(b) Cost of tractor operation.
(c) Cost of pump operation for lift irrigation.
(d) Economics of fertilizer use.
(e) Size and shape of plots and blocks for experimentation with forage crops-Cowpea.

Agricultural Engineering Section :

AE–1 Design, development and evaluation of forage seed collectors and harvesters.

(a) Grass seed collector.
(b) Forage harvester.
(c) Tractor-drawn irrigation channel-cum-bund-former.
(d) Mechanical chicory seed separator.

AE–3 Effect of mechanical harvesters on regeneration and production of multi-cut fodder crops.

AE–4 Design, development and evaluation of hay baler and crusher.

PLANT IMPROVEMENT DIVISION

Salient features

Germplasm collection of forage plants were strengthened with further additions raising the total number of collections to 4216 in grasses, 4462 in legumes and 159 in miscellaneous crops.

Promising range grass selections have been identified which included : IGFRI-S-3108 in *Cenchrus ciliaris* which gave 1246 q/ha in seven cuts (over a period of three years) as against 985 q/ha of Pusa Giant Anjan (control); IGFRI-595-1, 495-3, 3995-1 and 495-5 in *Dichanthium aunulatum* with cumulative green fodder yields (in three cuts) ranging from 221 to 264 q/ha as compared to 146 q/ha of control, Marvel-8; and in *Pennisetum pedicellatum*, high yielding selections namely IGFRI-S-3808-1 (1000 q/ha), 966-1 (960 q/ha) and 31-1 (930 q/ha).

In range legumes, several promising selections have been identified in Stylo (S-4214-1, S-96-1, S-4109-1 and S-230-1 for pure and as mixture with *Cenchrus* and in *Clitoria ternatea* (IGFRI-S-23-1, S-12-1, S-160-1).

In berseem a number of promising selections have been identified which included IGFRI-99-1 that proved outstanding in local and multilocational trials. Promising materials have also been isolated in *Vicia* (for pure as well as mixed cultivation with oats).

Multilocational tests of promising selections of cowpea and lucerne revealed consistency in yield superiority of selections IGFRI-S-457, S-978 and S-985 of cowpea and P. C. 2. P. C. 10 and P. C. 4 of lucerne. The above three cowpea selections also gave outstanding performance in the All-India Co-ordinated trials conducted at Jhansi. Among the entries of lucerne tested in trials under the auspices of All-India Co-ordinated Project, IGFRI-S-244 gave consistently higher yields.

In fodder sorghum, IGFRI-S-452 (424 q/ha) and IGFRI-S-427 (423 q/ha) gave higher green fodder yields than the control variety M. P. chari (371 q/ha) Fodder oat selections that outyielded kent (control) when cut at 50% bloom stage included IGFRI-S-3014, S-3026, S-3021, S-2660 and S-2688 and when cut at 60 and 100 days of sowing were S-3010, S-2636, S-3006, S-2672 and S-3022. Among the fodder oat entries that showed consistency in yield performance in co-ordinated trials were IGFRI-S-2688, IGFRI-S-3021, IGFRI-S-3026, IGFRI-S-2660 and IGFRI-S-3014.

Intervarietal and/or interspecific hybridization programmes in fodder oats and also in fodder sorghum were intensified.

Field screening of the germplasm collections against the prevalent diseases showed that none out of 128 lines of pea was resistant to leaf spot, powdery mildew and mosaic; all but 37 of the 195 oat varieties were resistant to leaf blight, leaf blotch and red leaf virus; one out of 10 lucerne cultivars was resistant to leaf spot, powdery mildew, and 46 out of 410 cowpea collections were resistant to leaf spot and mosaic virus.

Losses in green and dry matter due to mildew in 4 cultivars of methi and 10 of lucerne ranged from 25-63%, 51-83% and 18-65% and 14-84%, respectively.

In cowpea, among the granular formulation insecticides Carbofuran, Dipterex, Rogor and Endosulfan and among spray formulations, Endosulfan appreciably reduced the incidence of leaf hopper, flea beetle and semilooper. Yield losses in cowpea, in the absence of any chemical protection, was found to be as high as 27 per cent.

RESEARCH WORK DONE

PI-1 : INTRODUCTION AND EVALUATION OF FORAGE LEGUMES AND GRASSES

COLLECTION :

Germplasm collections of 18 grasses, 141 legumes and 12 in miscellaneous fodder crops were assembled, thereby bringing the total

to 4126 in grasses, 4462 in legumes and 159 in miscellaneous forage crops in the germplasm bank. These collections are being progressively evaluated.

1.1 : Introduction and evaluation of range grasses
(M. S. Yadav)

Cenchrus ciliaris :

Yield performance of 26 entries was assessed in a replicated trial under rainfed conditions from 1969-1972. Selection IGFRI-3108 gave higher cumulative green fodder yield of 1246 q/ha (in seven cuts) as compared to 985 q/ha produced by Pusa Giant Anjan.

Dichanthium annulatum :

In a varietal evaluation trial, involving 18 collections, IGFRI selections 495-1, 495-3, 3995-1 and 495-5 gave higher cumulative green fodder yields of 264, 258, 242 and 221 q/ha, respectively as compared to 146 q/ha of marvel-8 (control) under three cuts (May 1972, August 1972 and December 1972) taken during second year growth.

Pennisetum pedicellatum :

In a varietal evaluation trial, IGFRI-3808-1 gave maximum fodder yield of 1000 q/ha followed by IGFRI-966-1 and 32-1 giving 960 and 930 q/ha green fodder, respectively. Check variety T_1 gave 850 q/ha green fodder.

Based on superior performance over other entries including standard control varieties tested under all India Co-ordinated trials at various locations in India IGFRI selection 3108 in *Cenchrus ciliaris*, 495-1 in *Dichanthium annulatum* and 3808-1 in *Pennisetum pedicellatum* were recommended as promising by the III All India Workshop on forage crops.

1.2 : Introduction and evaluation of range legumes
(M. L. Magoon and M. S. Yadav)

STYLO

20 collections involving four species were tested in a replicated

trial as pure crop and in association with *Cenchuvs ciliaris*. Second and third cuts were taken in May 1972 and November 1972. *Stylosanthes gracilis*, *S. humilis*, and *S, sundaica* were at par in respect of green fodder yield. *S. mucronata* did not perform well under Jhansi conditions. As pure crop, *S. gracilis* (S-4214-1) gave maximum cumulative green fodder yield of 432 q/ha followed by *S. gracilis* (S-96-1), *S. humilis* (S-4109-1) and *S. sundaica* (S-230-1) giving 416, 410 and 400 q/ha cumulative green fodder, respectively under all the three cuts taken in December 1971, March 1972 and November 1972.

In Mixture, Stylo collections behaved in the same order as in the pure crop. *S. gracilis* (S-4214-1), *S. gracilis* (S-96-1), S. *humilis* (S-4109) and *S. sundaica* (S-230-1) gave respectively, 27.7, 24.3, 26.2 and 26.0 per cent higher dry matter yield under mixture as compared to pure crop of respective species.

Clitoria ternatea :

In a varietal evaluation trial involving 18 collections, the promising collections IGFRI-S-23-1, S-12-1, S-160-1 and S-7-1 gave green fodder yields of 320, 305, 301 and 290 q/ha, respectively in three cuts taken in November 1971, March 1972 and November 1972.

1.3 : Introduction and evaluation of cultivated legumes
(K. L. Mehra and M. S. Yadav)

BERSEEM

135 selections including tetraploids (T) and diploids (D) along with Pusa Giant berseem (T) were put in a replicated progeny row trial with a view to assessing the performance of individual progenies for different fodder attributes. Out of these, IGFRI 99-1 (T), 99-2 (T), 99-3 (T), 106-1 (T), 107-1 (T), 157-1 (T), 177-3 (D), 189-3 (D), 235-2 (Fahli), 187-2 (D), 103-3 (T), 183-1 (D) and 185-1 (D) gave higher green fodder yields of 844, 830, 814, 754, 778, 741, 728, 714, 704, 699, 666, 649 and 564 q/ha, respectively than 489 q/ha of Pusa gaint berseem under 3 cuts.

Vicia/Oats mixture :

13 collections of three *Vicia* species were evaluated under two cropp-

ing systems (i) Pure crop and (ii) as mixed crop with oats (var. kent) in alternate rows. *Vicia* collections when grown in pure stand yielded 36 to 127 q/ha but as mixed crop the fodder yield ranged from 112 to 193 q/ha. In pure stand, *V. sativa* S-119-2, *V. narbonensis* S-115-1 and *V. sativa* S-119-1 were outstanding by virtue of their higher green fodder yields of 127, 124 and 113 q/ha, respectively. Under mixed cropping, oats+*V. desycarpa* (S-114-1) gave maximum fodder yield of 193 q/ha followed by oats+*V. nervonensis* (S-115-1), oats+*V. desycarpa* (114-2) and oats+*V. sativa* (119-2) which gave 188, 175 and 162 q/ha green fodder, respectively. In addition to higher yields *V. desycarpa* produced higher number (170) and weight (1.80 g) of nodules per plant as compared to 150 (number) and 0.235 g (weight) in *Vicia sativa*. *V. nervonensis* though produced a higher number (225) of nodules than *Vicia desycarpa*, the weight of nodules (1.30 g) per plant was lower due to the smaller size of the nodules.

GUAR

In a varietal evaluation trial involving 20 entries, IGFRI-212 gave maximum green fodder yield of 257 q/ha followed by IGFRI-1538, -1535, -38, -219 and -197 giving 234, 231, 211, 204 and 207 q/ha green fodder yields, respectively.

SOYBEAN

In a varietal evaluation trial involving 20 selections, IGERI-S-1889 and S-2212 gave higher green fodder yields of 288 and 247 q/ha as compared to 224 q/ha produced by standard control, variety T_1.

PI-2 : PRODUCTION AND QUALITY BREEDING IN FODDER GRASSES

2.1 : Production and quality breeding in fodder sorghum and oats
(M. L. Magoon, K. L. Mehra, R. Krishnan, Bhagmal, D. S. Katiyar and K. C. Velayudhan)

(a) **Screening of Germplasm collections :**

SORGHUM :

Fodder attributes of 50 germplasm collections grown in 3 m long rows were studied. The observed variations were 128 to 358 cm for

plant height, 0.7 to 2.0 cm for stem girth, 10 to 16 for leaf number, 40.2 to 90 0 cm for leaf length, 2.9 to 9.0 cm for leaf width and 58 to 105 days for 50% blooming. Ten promising lines have been isolated for hybridization work.

OATS

157 cultures of fodder oats were studied for floral and seed characters. A wide range of variation was observed for several of these characters. The variations were from 6.7 to 17.7 for panicle number, 3.7 to 7.7 for number of internodes on the panicle, 20.0 to 52.0 cm for the length of upper internode, 16.3 to 43.0 cm for the length of panicle, 29.7 to 124.0 for number of spikelets per panicle, 21.7 to 197.3 for number of grain per panicle, and 1.3 to 40.7 g for yield per plant. Fifteen cultures have been isolated on the basis of higher grain yield and other seed characters.

(b) Genetical studies :

In order to study the mode of inheritance of chlorophyll deficiency in a culture of oat, crosses were made using several *Avena* cultures. The seeds obtained from such crosses were sown and F_1 plants were raised. All the F_1 plants studied showed no chlorophyll deficiency.

(c) Cytogenetical studies :

(i) Irradiation studies : The M_1 generation of *A. sativa* and *A. fatua* populations grown on plant-and tiller-basis alongwith their untreated controls were screened for various fodder characters and single plant selections for one or more characters were made. The seeds from selected plants (17 *A. sativa* M_1 plants and 31 M_1 plants of *A. fatua*) were sown in rabi 1972 for further studies.

Irradiated seeds (20, 40 and 60 Kr) of five cultures belonging to the three hexaploid species, *Avena sativa, A. byzantina* and *A. fatua* were sown along with the untreated controls for further studies. Seed germination decreased with increasing dosage of irradiation and over untreated control.

(ii) *Cytological studies on Avena interspecific hybrids* : The meiosis of F_1 interspecific hybrids involving hexaploid species of *Avena* was studied. Meiotic abnormalities were recorded in the cross involving *A sativa* and *A. fatua.*

(d) **Breeding through selection and/or hybridization :**

SORGHUM

(a) *Evaluation* : Ten promising selections were evaluated under rainfed conditions, alongwith the control veriety, M. P. chari, for their yield performance, when cut at 50 per cent flowering stage. The data on their green fodder yield, days taken to 50 per cent bloom, plant height, leaf number, stem girth, sugar per cent and dry matter content were recorded. Green fodder yields of selections IGFRI-S-452 (424 q/ha), IGFRI-S-427 (423 q/ha) and five other selections eventhough were higher than that of M. P. chari (371 q/ha), the yield differences were not significant. The selections with high green fodder and dry matter yield potentialities were IGFRI-S-452, IGFRI-S-427, IGFRI-S-493, IGFRI-S-491, IGFRI-S-309 and IGFRI-S-758. Almost all the selections reached 50 percent bloom stage simultaneously with M. P. chari. Selections IGFRI–S–427 (13.2) and IGFRI-S-491 (12.5) bore more leaves than M. P. chari (12.2) and the sugar contents of IGFRI-S-493 (7.9%), IGFRI-S-352 (6.6%) and IGFRI-S-452 (5.9%) were higher than that of M. P. chari (4.5%).

In another trial, twelve sudan grass hybrids (bred in U, S. A.) received through the courtesy of Dr. Hittle, Project Adviser, J. N. Krishi Vishwa Vidyalaya, Jabalpur were evaluated for their yield performance when cut at 50 per cent bloom stage using M. P. chari and a local variety of Hyderabad as controls. Three hybrids, De Kalb Sx-16 (360 q/ha), Frontier Hidan-35 (336 q/ha) and Funks-78F (331 q/ha) outyielded M. P. chari (235 q/ha) in green fodder yields.

Advancing of hybrid generations :

The hybrid progenies of inter-varietal crosses among selected parents were raised along with their parents and screened for fodder yield characters. These were drawn from 15 F_2 crosses, 21 F_3 crosses,

five F_5 crosses and six F_6 crosses. Promising materials were isolated in in these progenies for further studies.

OAT

(a) *Evaluation* : Fifteen promising selections were evaluated along with the control variety kent for their yield performance when cut at the 50 per cent bloom stage (single cut). The data on days to 50 per cent bloom, plant height, stem thickness, leafiness and dry matter (percentage) were recorded. Selection, IGFRI-S-3014 (478 q/ha) gave significantly higher green fodder yield than kent (363 q/ha). The green fodder yields of some of the other selections IGFRI-S-3026 (425 q/ha), IGFRI-S-3021 (422 q/ha), IGFRI-S-2660 (406 q/ha), IGFRI-S-3015 (401 q/ha), IGFRI-S-3022 (398 q/ha), IGFRI-S-2674 (390 q/ha) and IGFRI-S-2688 (374 q/ha) were also higher than that of kent. In comparison to kent with leaf stem ratio of 0,26 (dry matter basis) the selections, IGFRI-S-3014 (0.32), IGFRI-S-3021 (0.31), IGFRI-S-3026 (0.30), IGFRI-S-3008 (0.29), IGFRI-S-3010 (0.27) and IGFRI-S-2674 (0.28) were more leafy while, IGFRI-S-3026 (68 days), IGFRI S-2670–(72 days), IFGRI-S-2760 (72 days) and IFGRI-S-2672 (72 days) were early blooming (75 days in kent).

A multicut (two cuts at 80 and 120 days of sowing) trial was also conducted using fifteen promising selections and kent (control). The differences among the varietal yields (green fodder) in the first and second cuts and cumulative yields in comparison to kent were not significant, except in case of IGFRI-S-3010 for first cut. The cumulative green fodder yields of IGFRI-S-3010 (459 q/ha), IGFRI-S-2636 (454 q/ha), IGFRI-S-3006 (449 q/ha), IGFRI-S-2672 (433 q/ha) and IGFRI-S-3022 (406 q/ha) were higher than that of kent (401 q/ha). Among the selections that gave higher yields than kent in first cut were IGFRI-S-3010 (304 q/ha), IGFRI-S-2636 (294 q/ha) and IGFRI-S-3021 (291 q/ha) and in second cut was IGFRI-S-3 (235 q/ha). The green fodder yields of kent being 221 q/ha in first cut and 179 q/ha in second cut, Selections IGFRI-S-3010, IGFRI-S-3006 and IGFRI-S-3018 were more leafy than kent besides being high yielders.

(b) *Hybridization* : Twelve crosses involving six promising

stocks of fodder oats were made. The parental lines used in these crosses exhibited differences for fodder attributes such as plant height, days taken to 50% flowering, leafiness, leaf number, tiller number etc.

(c) *Advancing of the hybrid generations* : The F_1 hybrids sown during November, 1971 including those of interspecific crosses were studied along with parents for fodder attributes. The seed obtained from these plants were sown.

The F_2 generations of seven crosses were screened for fodder characters such as plant height, leaf length, leaf width, leaf number, tiller number, stem girth, leaf-stem ratio etc., and in respect of all the characters a wide variation, transgressing parental values, was recorded. Data for similar characters were also recorded in the F_3 populations of seven crosses and in the F_4 population of one cross.

PI-4 : PRODUCTION AND QUALITY BREEDING IN CULTIVATED FODDER LEGUMES

4.1 : Breeding varieties for high fodder yield and quality in cowpea.

(M. L. Magoon, K. L. Mehra, Amar Singh and C. B. Singh)

(a) 500 germplasm collections were grown in single row of 4 metre length and observations on general vigour, leafiness, maturity, pod synchrony and seed filling were recorded. Ten promising types possessing the above characters singly or in combination have been identified.

(b) 10 promising selections of cowpea were grown at Jhansi, Bareilly, Varanasi, Dehradun, Meerut and Mathura in replicated trials. Data recorded on fodder yields indicated the significant superiority of improved varieties viz., IGFRI-S-457, IGFRI-S-978and IGFRI-S-985 yielding (average of five locations) 340, 308, and 388 q/ha of green fodder in a single cut taken at pod formation stage. The range in yields over the locations were 280-343, 285-322 and 266-359 q/ha in IGFRI-S-985, IGFRI-S-978 and IGFRI-S-457, respectively.

(c) In an initial evaluation trial conducted at Jhansi, Bareilly, Meerut, Mathura and Varanasi with 20 promising selections, the data

on fodder yield again revealed the significant superiority of IGFRI-S-457, IGFRI-S-978, IGFRI-S-985 and also of IGFRI-S-998, IGFRI-S-1376, IGFRI-S-1341, IGFRI-586 and IGFRI-S-591 as compared to others. The maximum yields obtained over the five locations in IGFRI-S-1376, IGFRI-S-1341, IGFRI-S-586 and IGFRI-S-591 were 370, 318, 318 and 318 q/ha respectively.

4.2 : Variety synthesis for high fodder yield and quality in lucerne
(K. L. Mehra, C. B. Singh and K. S. Kohli)

218 germplasm collections were rown in isolation for the maintenance of genetic purity and preliminary evaluation in 1 sq. m. plots. 10 different species of the genus *Medicago* were also grown for screening and isolation of cultures possessing greater persistency for pasture use. Four types possessing good regrowth, good seed set and drought endurance were selected.

A replicated trial of 12 open pollinated progenies obtained from polycross nursery, a composite of 12 O. P. progenies in equal proportion and Sirsa-9 as control was conducted. The data (recorded 65 days after sowing) on the fodder yield indicated significant differences amongst the cultures. P. C. 2 gave the highest fodder yield (204 q/ha) followed by P. C. 8 (191 q/ha), P. C. 6 (178 q/ha) and P. C. 10 (176 q/ha) in the first cut. In the 2nd cut, P. C. 2, P. C. 1 and P. C. 10 were superior to the rest yielding 261, 221 and 214 q/ha of green fodder respectively while in the 3rd cut, P. C, 2, P. C. 3, P. C. 4 and P. C. 10 were superior with a yield potential of 230, 260, 208 and 200 q/ha, respectively.

In the cumulative yield of three cuts, P. C. 2 gave 695 q/ha followed by P. C. 10 (591 q/ha), P. C. 4 (581 q/ha) as compared to 477 q/ha recorded in check–Sirsa–9.

4.3 : Variety construction for high yield and quality in velvet bean
(Amar Singh and K. S. Kohli)

13 genetic stocks in a replicated initial evaluation trial and 4 improved selections in the final evaluation trial with four replicates were sown. In the final evaluation trial, IGFRI-S-2276-2–5 and 2284–5 gave higher green fodder yields of 398 and 389 q/ha. Further,

IGFRI-S-2276-2-5 showed a greater overwintering capacity as compared to other varieties which had dried in the winter season. This variety possesses considerable degree of tolerance to defoliation also.

PI-5 : PRODUCTION AND QUALITY BREEDING IN PASTURE LEGUMES

5-1 : Variety construction for high yield, quality and cold tolerance in carpet legume

(C. B. Singh, K. S. Kohli aud Amar Singh)

A final evaluation trial with four promising selections was conducted at Jhansi, Lucknow, Meerut and Dehradun. The data recorded on fodder yield revealed the overall superiority of IGFRI-S-2214-I and IGFRI-S-2214-II which yielded 240 q/ha and 195.5 q/ha, respectively.

In an initial evaluation trial with 10 entries, conducted at Jhansi, IGFRI-1649-I and IGFRI-S-2218 were found promising, yielding 187.5 q/ha of green fodder in a single cut taken at pod formation stage.

PI-6 : PLANT PATHOLOGICAL INVESTIGATIONS ON FORAGE CROPS

6.1 : Prevalence and distribution of plant diseases

(S. T. Ahmad)

Incidence of plant diseases in forage crops were recorded through periodic surveys conducted at Central Research Farm, Jhansi, Mathura, Bareilly, Lucknow and Varanasi which are as follows :

Crops	Diseases recorded
Oats	Leaf blight, leaf blotch, barley yellow dwarf virus.
Dichanthium sp.	Rust, leaf spot.
Sehima sp.	Rust (new record, being investigated)
Heteropogon sp.	Rust, leaf spot.
Isellema sp.	Leaf spot, leaf curl (being investigated).
Lucerne	Leaf spot, downy mildew, powdery mildew, rust, bacterial leaf spot.

Berseem	Leaf spot, bacterial leaf spot, mosaic virus.
Cowpea	Leaf spot, bacterial leaf spot, mosaic virus.
Sem	Leaf spot, bacterial leaf spot, mosaic virus.
Pea	Powdery mildew, bacterial leaf spot, mosaic virus.
Mucuna	Rust, leaf spot (at Lucknow).
Arhar	Leaf spot, pigeonpea sterility virus (being confirmed)
Jowar	Leaf spot, leaf blight, becterial blight.
Sarson	Leaf spot.

Leaf spots, mildew and virus on wild plants were also recorded. Investigations are in progress to establish the relationship of these diseases with that on forage crops.

One hundred twenty eight lines of pea were screened for field resistance to leaf spot, mildew and mosaic virus under natural conditions. 126, 31 and 24 collections were resistant to virus, leaf spot and mildew respectively. One culture was resistant to leaf spot and mildew and none was found resistant to all the three diseases.

Twenty varieties of methi grown under three different doses of fertilizer were screened for the severity of powdery mildew disease. The severity was scored under four categories viz., (a) disease upto 20%, (b) 21 to 40%, (c) 41 to 60% and (d) above 60%. Each variety showed a range of infection from 0 to above 90 per cent. The disease development on these varieties was observed to be independent of the fertilizer doses.

195 oat cultivars including 20 promising, were screened against leaf blight, leaf blotch and red leaf virus. 18, 16 and 3 oat cultivars were susceptible to leaf blight, leaf blotch and red leaf virus, respectively.

410 cowpea collections were screened against leaf spot, bacterial leaf spot and virus. A high proportion of cultivars (23.3%) showed resistance to virus and bacterial leaf spot, 8.3 per cent cultivars were

resistant to leaf spot and bacterial leaf spot and 5.9 per cent cultivars were resistant to leaf spot and virisus. Cultivars showing resistance to the three diseases were 11.4 per cent.

6.2 : Host-parasite relationship
(S. T. Ahmad)

The mode of inheritance of disease resistance was studied in oat and peas (hosts).

Oat germplasm collections comprising 22 species representing diploids, tettraploids and hexaploids were screened for their field performance against prevalent diseases. A few interspecific crosses have been made in order to study the genetics of disease resistance.

In peas. F_1 hybrids involving 15 genetic stocks were screened for their field resistance to mildew and bacterial leaf spot diseases and few F_1 lines exhibiting field resistance to one or the other disease were identified.

6.3 : Effect of plant diseases on yield, quality and physiology of forage crops
(S. T. Ahmad)

(i) Losses in four varieties of methi due to mildew were determined on the basis of average yield of 3 plants each from the four disease categories viz., 5-20, 21-40, 41-60 and above 60%. It was found that loss in green weight ranged from 25 to 63 per cent and 51 to 83 per cent in dry matter.

(ii) Similarly losses in ten varieties of lucerne due to mildew were also estimated. It was found that per cent decrease in green weight over the control were 58-65, and 14 to 84 in dry matter. The losses in green weight and dry weight of these varieties appeared to be uncorrelated.

6.4 : Standardization of control measures
(S. T. Ahmad)

(i) In order to evaluate the efficacy of fungicides and antibiotics on the control of leaf spot of guar and soybean, pretreated 12 guar and

8 soybean cultivars were grown in micro plots and sprayed with Dithane M-45, Streptocyclin and Agrimycin, 30 days after sowing. These applications were repeated 2 times at 15 days intervals. A week after the last application, presence of leaf spots were recorded. The experiment needs to be repeated due to uneven germination and growth.

(ii) To evaluate the efficacy of four fungicides for the contrcl of powdery mildew, 2 cultivars each of methi and lucerne were grown in microplots with three replications. These were sprayed with Dithane M-45, Streptocycline, Agrimycin and Vitavex during the first appearance of powdery mildew and repeated twice at 20 days interval. the results are being awaited.

PI-7 : ENTOMOLOGICAL IVESTIGATIONS ON FORAGE CROPS

7.1 : Evaluation of losses in green fodder yield due to damage caused by major insect pests of cowpea and lucerne

(Shri Ram)

A. COWPEA

The experiment was repeated for the second year, Paired plots were used for estimating losses due to pests in cowpea. One of the paired plots was protected by using Carbofuran at the rate of 3 g/m row and the other left for natural infestation. The results revealed that there was a loss of 34 per cent of green fodder yield in the untreated plots of cowpea.

B. LUCERNE

The trial was laid out for the second year. Paired plots were used for assessing the losses due to pests in lucerne. One of the paired plots was protected by granular application of Thiodemeton (3 g/m row) at the time of sowing and also by foliar application of carbaryl (0.1%) at the advance stage of crop growth and the other was left for natural infestation. The results revealed that there was a loss of 15 per cent of green fodder yield in the untreated plots of lucerne.

7.2 : Relative efficacy of common and safer pesticides i n the the control of pests of cowpea, lucerne and sorghum

(Shri Ram)

A. COWPEA

(i) The experiment with seven insecticides of granular formulation, viz., Carbofuran, Dipterex, Rogor, Sumithion, Carbaryl, Endosulfan and Lindane along with a control (no insecticide) was conducted with a view to testing their efficacies against the leaf hopper, flea beetle and semilooper in cowpea. The insecticides were applied in furrows over the seed at the rate of 3 g/m row. All the insecticides reduced the incidence of these insects significantly as compared to that of the control. Among the insecticides, Carbofuran, Dipterex, Rogor and Endosulfan were better and statistically at par. The green fodder yield of cowpea was maximum (350 q/ha) in Carbofuran followed by Endosulfan (347 q/ha). The yield from control plots was 263 q/ha.

(ii) Similar trial was conducted with insecticides of spray formulation, viz., Malathion, Endosulfan, Rogor, Sumithion, Nuvan, Phosphamidon (0.04%) and Carbaryl (0.1%). The insecticides were sprayed at 40 days crop growth. All the insecticides proved effective in reducing the incidence of leaf hopper, flea beetle and semilooper significantly as compared to that of the control (no insecticide). Among the insecticides, Endosulfan was most effective. Carbaryl, Sumithion, Rogor, Phosphamidon and Malothion came next and were at par with each other.

The green fodder yield of cowpea from plots treated with Malathion was maximum (336 q/ha) followed by Carbaryl (335 q/ha), Phosphamidon (325 q/ha) and Endosulfan (292 q/ha). The control plot yields were of the order of 252 q/ha.

B. LUCERNE

(i) Eight insecticides of granular formulation applied at the time of sowing in furrows over seeds along with a control (no insecticide), were tested for their efficacies against the insect pests of lucerne. The insecticides were Thiodemeton, Lindane, Sumithion, Endosulfan, Rogor,

Malathion, Dipterex (@ 3 g/m row) and Themet (@ 1.5 g/m row). The observations made so far revealed that the insecticides Malathion, Lindane and Endosulfan were quite effective in controlling the leaf hopper in Lucerne.

(ii) A separate trial was laid out in lucerne with nine insecticides., viz., Malathion, Endosulfan, Pyrocolloid, Lindane, Rogor, Sumithion, Phosphamidon, Nuvan (0.04%) and Carbaryl (0.1%), applied as spray formulation, alon g with a control on 4o days old crop to test their efficacies against leaf hopper. The results indicated that the insecticides, Carbaryl, Phosphamidon and Nuvan were quite effective in reducing the incidence of leaf hopper.

PERFORMANCE OF IMPROVED VARIETIES UNDER ALL-INDIA COORDINATED TRIALS

BERSEEM

IGFRI contributed 5 entries for a trial of 13 entries. IGFRI-99-1 gave 13.92, 10.39, 21.78 and 46.83 per cent higher yield over pusa giant berseem at Jhansi, Delhi, Ludhiana and Jabalpur, respectively. It was recommended as promising for prerelease multiplication at the Third All-India Workshop on forage crops.

GUAR

Under All India Forage Coordinated trials, IGFRI-212 ranked first both in green and dry matter at Jodhpur, Hissar and Jhansi locations. It was recommended as promising for pre-release multiplication at the Third All-India Workshop on forage crops.

OATS

Fifteen entries were contributed by I. G. F. R. I. for the initial Evaluation trial conducted at Jhansi and at Hissar. At Jhansi, the variety IGFRI-S-3022 gave the highest green fodder (454 q/ha) and dry matter (109 q/ha) yields when cut at 50 per cent bloom stage. Among other rankers in green fodder yields were IGFRI-S-2638 (407 q/ha) and IGFRI-S-3017 (394 q/ha) and in dry fodder yields were IGFRI-S-2674 (92.4 q/ha) and IGFRI-S-3017 (83.4 q/ha).

The I. G. F. R. I. had contributed nine entries each for the two Final Evaluation trials (single cut and multicut) conducted at Jhansi and at six other locations namely, Palampur, Pantnagar, Hissar, Kanke, Kalyani and Ludhiana.

In the single cut trial at Jhansi, the top three (highest yielding) entries were IGFRI-S-3021 (463 q/ha), IGFRI-S-3008 (448 q/ha) and IGFRI-S-3026 (446 q/ha) on the basis of green fodder (at 50 per cent bloom stage) and IGFRI-S-3026 (96 q/ha), IGFRI-S-3014 (90.4 q/ha) and IGFRI-S-3021 (88 q/ha) on dry matter yield wise.

For the multicut trial, nine entries were contributed by I.G.F.R.I. In the trial conducted at this centre two cuts (80 and 120 days after sowing) were taken. IGFRI-S-2681 gave the highest cumulative yield of green fodder (344 q/ha) and dry matter (74 q/ha). The other promising entries on the basis of green fodder yields being IGFRI-S-2660 (335 q/ha), IGFRI-S-2705 (315 q/ha) and IGFRI-S-3010 (313 q/ha) and on the basis of dry matter yields were IGFRI-S-2705 (70.4 q/ha), IGFRI-S-2660 (67.2 q/ha) and IGFRI-S-3018 (60.3 q/ha).

Reports from other centres have also indicated yield superiority of IGFRI entries in terms of both green and dry matter production in one or more locations (*Vide* Progress Report of the All India Coordinated Project for Research on Forage Crops, 1971-72). Among the entries of the final evaluation trial-single cut, IGFRI-S-2660, IGFRI-S-2688, IGFRI-S-3014, IGFRI-S-3021 and IGFRI-S-3026 were among the top three in respect of green fodder yields in more than one loc ation and the latter four entries gave similar performance in respect of dry matter production also. Additionally, IGFRI-S-3021 was also among the highest crude protein yielders in three locations for which such data are available. Similarly, in the Final Evaluation trial-multicut, the IGFRI entries that had the ranking among the top three in more than one locations were : IGFRI-S-3010, IGFRI-S-3021, IGFRI-S-3026 in respect of green fodder yields, and in terms of dry matter yields in addition to these three, were IGFRI-S-3018, IGFRI-S-2672 and IGFRI-S-2660. The latter was the highest crude protein yielding entry in both the locations for which such data were available.

IGFRI-S-2688 yielding upto 583 q/ha of green fodder has been recommended for release as single cut variety based on its overall superior performance in the various locations. The other entry, IGFRI-S-3021, was recommended as promising dual purpose type on account of its consistent superiority in yield performance in both single (upto 556 q/ha) and multicut (upto 616 q/ha) trials at different locations.

COWPEA

In cowpeas, the trial conducted with seven entries in the summer season (April–June) revealed the consistentsuperiority of IGFRI –S–450 and IGFRI-S-457 with high yield potentials (over 500 q/ha) of green fodder in two cuts. IGFRI-S-450 was recommended for release for general cultivation while IGFRI-S-457 was considered promising.

In the trials conducted in kharif season (July–October) with six entries, IGFRI–S–457, IGFRI–S–978, IGFRI–S–985 showed the consistent superiority at all locations in forage yield and crude protein content. These promising selection yielded 439.9, 449.7 and 481.1 q/ha of green fodder respectively as compared to 325.4 q/ha recorded in Sirsa–10. Their protein content was also higher (17.7–18.9%) as compared to 17.3% in Sirsa–10. IGFRI–S–978 and IGFRI–S–985 were considered promising at the forage workshop.

LUCERNE

In lucerne, a trial with 10 entries revealed the significant and consistent superiority of IGFRI–S–54 and IGFRI–S–244 over other varieties with yield potentials of over 800 q/ha as compared to 666 q/ha recorded in Sirsa–9. IGFRI S–244 was recommended for release for cultivation throughout the country while IGFRI–S–54 was considered promising.

Research contemplated

1. Intensification of germplasm collections in forage grasses and legumes through various agencies, correspondence, collection trips etc.

2. Evaluation of germplasm collections of pasture grasses and legumes for their fodder yield attributes.

3. Intensification of efforts on variety construction programme of fodder legumes, especially through intraspecific hybridization, in lucerne, cowpea,Velvet bean, *Dolichos* etc.

4. Initiation of studies on seed production in the above legumes.

5. Induction of colchiploidy in dryland legumes viz. *Atylosia, Phaseolus trilobus, P. aconitifolius* etc.

6. Strengthening of the programme on production and quality breeding in fodder sorghum and oats and also in range grasses namely *Cenchrus* and *Sehima.*

7. Analysis of nature of resistance in fodder oats for crown and stem rust diseases.

8. Evaluation of fungicides and antibiotics for control of foliar diseases of guar. lucerne, and oats.

9. Assessment of the effects of important plant diseases on the yield, quality and physiology of selected forage crops.

10. Determination of the efficacy of different dosages of promising and safer insecticides against pests of important forage crops.

11. Estimation of losses in fodder quality (protein content) following pest damage in important forage crops.

12. Assessment of relationships between insect pests incidence and cultural practices such as dates of sowing and levels of fertilization.

SOIL SCIENCE AND AGRONOMY DIVISION

Salient features

In the overlapping cropping system consisting of berseem+Japan sarson inter-planted with hybrid napier and growing of cowpea in the interrow spaces during *kharif*, a total yield of 2599 q/ha green fodder (476 q/ha D. M.) averaging to a green fodder production of 7.1 q/ha/day was obtained this year–the II year of the experiment.

It was found possible to grow successfully fodder mixtures (M. P. chari+cowpea, bajra+cowpea or maize+cowpea) during the gap period (April–June) or wheat – *jowar* (grain) rotation which is also one of the lean periods for green fodder availability. Each of these mixtures gave a green fodder yield of about 300 q/ha.

Spray grade urea was found superior to fertilizer grade urea as a source of N for foliar spray in M. P. chari, teosinte and oats grown for fodder.

In M. P. chari (fodder sorghum), a seed rate of 60 kg/ha was found optimum for fodder production

In berseem and oats, it was found that by rational use of irrigation, economy in water use could be ensured without affecting their seed production. Thus, in berseem, application of two irrigations at 15 and 30 days after the third cutting resulted in a seed yield of 6.04 q/ha, as against a seed yield 4.46 q/ha for four irrigations at 15 days interval starting from the third cut. In oats, two irrigations at late tillering nd flowering stages were found sufficient for normal seed production.

RESEARCH WORK DONE

SA–1 : EVALUATION OF GENOTYPIC RESPONSE OF FODDER CROPS

(Gopichandra, M. N. Mishra, N. D. Mannikar and S. N. Tripathi

Comparative performance of d ifferent strains of tetraploid berseem

This was the third year of the experiment. Nine tetraploid strains

with one diploid as control were evaluated using seed rates of 25 and 50 kg/ha each. Twenty kg N and 80 kg P_2O_5/ha was applied to the crop as basal manuring. Three cuts were taken for fodder and thereafter the crop was left for seed production.

The green fodder yields of different strains of tetraploid and diploid, which ranged from 571 to 638 q/ha (75.9 to 84.8 q/ha D. M.) for the aggregate of 3 cuts did not show any significant differences. The yield obtained at 50 kg/ha seed rate (611 q/ha green fodder and 81.3 q/ha D. M.) was significantly higher to that obtained at 25 kg/ha seed rate (590 q/ha green fodder and 78.4 q/ha D. M.). The interaction between varieties and seed rates was not significant.

The seed yields for various tetraploid strains and diploid one, ranging from 423 to 517 kg/ha, also did not differ significantly. The seed yields obtained at different seed rates were also *at par*. The interation between varieties and seed rates was not significant.

Comparative performance of varieties of oats under different levels of nitrogen under phosphate manuring

This was the second year of the experiment. Three varieties of oats, viz., EC 13044, EC 13594 and Kent were grown under three levels levels of phosphate (0, 30 and 60 kg P_2O_5/ha) and four levels of nitrogen (0, 40, 80 and 120 kg N/ha. A common fertilizer dose of 25 kg K_2O/ha was given to all the plots at sowing. Phosphate and low dose of 40 kg N/ha were applied basal at sowing; and half of the 80 and 120 kg N was applied basal at sowing and the remaining half two months after sowing.

Result showed that there were no significant differences among the three oat varieties. The variety EC 13044 (389 q/ha green fodder and 98.5 q/ha D. M.) gave higher green fodder yield than EC 13594 (378 q/ha green fodder and 93.9 q/ha D. M.) and the popular variety Kent (372 q/ha green fodder and 92.4 q/ha D. M.). The differences due to the phosphate and nitrogen manuring were significant in respect of both green fodder and dry matter yields. Increasing levels of phosphate gave increased yield and the highest green and dry matter yields of 420 q/ha and 104 q/ha respectively were obtained with 60 kg P_2O_5/ha.

The yields for no phosphate treatment was 354 q/ha (85.7 q/ha D. M.). There was significant response to nitrogen manuring. The green fodder yield of 466 q/ha (117.7 q/ha D. M.) obtained with 120 kg N/ha was the highest and was 201 q/ha (49.5 q/ha D. M.). 93 q/ha (25.9 q/ha D. M.) and 52 q/ha D. M.) more than the green fodder yields obtained with 0, 40 and 80 kg N/ha, respectively.

The three two factor interactions were significant in case of green fodder only. Data on green fodder yield showed that while the two EC varieties gave increasing yields with increasing phosphate levels, the standard variety Kent did not show this trend. While EC 13044 and standard variety Kent gave normolly good yields (291 and 281 q/ha green fodder, respectively), EC 13594 gave lower green fodder yield (226 q/ha) under no nitrogen treatment. However, the performance of EC 13594 was most pronounced at 120 kg N/ha level, recording significantly higher yield (489 q/ha green fodder and 121.3 q/ha D. M.) than kent (448 q/ha) green fodder and 114.3 q/ha D. M.). Nitrogen without phosphate gave poor yields but its efficiency increased when combined with phosphate. Results of phosphorus estimation showed that phosphorus content of oat increased with increasing phosphate levels. Phosphorus content of plants varied from 0.092% for no phosphate to 0.10% for 30 kg P_2O_5/ha and 0.128% for 60 kg P_2O_5/ha. Amongst the oat varieties, highest phosphorus content of 0.117% was recorded in EC 13044 followed by Kent (0.118%) and EC 13494 (0.103%).

SA—2 : CULTURAL MANAGEMENT AND FERTILIZER USE INFODDER CROPS

(M.N. Misra, N.D. Mannikar, Gopichandra, S. N. Tripathi and P. R. Sreenath)

Effeet of late application of nitrogen on fodder and protein yield of oats (kent)

The trial was repeated for the third year. There were two treatment series with 60 and 40 kg N/ha basal application; 60 kg N/ha (basal) series received top dressing of N at 15 and 30 kg N/ha each at 15 days before flag leaf and at flag seaf stage (75 and 90 days) respectively. In addition, N treatment 60 kg N/ha(basal) was also included as a

control. 40 kg N (basal) series received 20 kg N/ha at 60 days after sowing. Further, this series also received 15 and 30 kg N/ha each at 15 days before flag leaf and at flag leaf stage respectively. In this series the control treatment was 40 kg (basal)+20 kg (at 60 days after sowing) N/ha. The crop was harvested at 50% flowering (103 days).

Results indicated that the treatments differed significantly with respect to green and dry matter yields. Both the series were statistically at par showing that there was no significant difference between the applications of 60 kg N/ha wholly as basal or 40 kg (basal)+20 kg (at 60 days after sowing) N/ha. Increasing the N level for top dressing from 15 to 30 kg N/ha increased only the green fodder significantly, the increase being 45 q/ha. The green fodder yield was 396 q/ha at 15 kg N/ha. Time of application (15 days before flag leaf stage or at flag leaf stage) had no effect either on green fodder or dry matter yields. Interaction between N-levels and time of application was not significunt.

Comparison of spray grade and fertilizer grade urea in relation to fodder yield and crude protein of oats (kent)

Trial was repeated for the second year. The efficiency of spray grade urea—SGU (low biuret content - maximum 0.3%) was compared with fertilizer geade urea - FGU (over 0,7% biuret content). SGU was obtained through the kind courtesy of M/s Shriram Fertilizers. Treatments comprised of soil and foliar applications as FGU and foliar application as SGU of 30 kg N/ha (over 60 kg N/ha basal) each at 60, 75 and 90 days growth. A basal application of 60 kg N/ha was included as control treatment. The crop was harvested at 50% flwering (105 days),

Results indicated that top dressing of 30 kg N/ha either as soil application or foliar application resulted in significant increase in green fodder yield over that obtained at 60 kg N/ha (basal). The differences between the green fodder yields due to soil and foliar applications were not significant. Although a yield increase of 21.9 q/ha was obtained due to foliar spray of SGU over the same amount applied as foliar spray of FGU, the difference was not significant. Time of top dressing of N. showed significant effect. Highest average yield of green fodder (475 q/ha) was obtained when the top dressing of N

was done 60 days after sowing. The Interaction between grades of urea and time of application was significant. A maximum of 485 q/ha of green fodder was obtained when SGU was sprayed 60 days after sowing.

Similar trend was observed with respect to dry matter yield, although the differences due to treatments were statistically not significant. Regarding crude protein yield, top dressing of 30 kg N/ha on an average resulted in significant increase of 177 kg/ha over the 476 kg/ha obtained at 60 kg N/ha (basal). Neither the grade of urea nor the time of its application had effect on C. P. yieid.

Effect of varying seed rates on green and dry matter production of M. P. Chari

The experiment was repeated for the second year. Six seed rates viz., 30, 40, 50, 60, 70 and 80 kg/ha were tried using a randomised block design with five replications. The crop received 60 kg N and 50 kg P_2O_5/ha basal at sowing and 30 kg N/ha as top dressing 35 days after sowing. The crop was harvested at 50% flowering.

Increasing seed rates gave increased green fodder and dry matter yields upto the seed rate of 70 kg/ha. The seed rate of 60 kg/ha gave an average yield of 457 q/ha of green fodder (113 q/ha D. M.) and was significantly superior to 30, 40 and 50 kg/ha seed rates. Increasing the seed rates beyond 60 kg/ha gave no added advantage.

Efficiency of nitrogen application for fodder production of M. P. Chari (fodder sorghum) grown under rainfed conditions

The trial was repeated for the third year on heavy (Bhojla clay loam) and light (Bharari sandy loam) soils. The treatments consisted of 0, 30, 60 and 90 kg N(ha. In addition, 60 kg N treatment was given as spilit application in the ratio of 1.1 and 90 kg N treatment in the ratios of 1:2, 2:1 and 1:1. The 2nd split does of the nitrogen was given as top dressing in qetween the rows of the crop 41 days after sowing. All plots received a basal dose of 30 kg P_2O_5/ha at sowing.

On Bhojla clay loam soil, 90 kg N/ha applied at sowing gave the highest green fodder yield of 263 q/ha (93 q/ha D. M.), an increase

of 163% over control (no nitrogen). Split application of nitrogen did not increase the yield over the entire dose of nitrogen applied basal at sowing.

The trend of nitrogen response on Bharari Sandy loam soil was similar to that on Bhojla clay loam soil. Significant increasc in the green fodder yield was obtained upto 90 kg N/ha, recording the maximum of 302 q/ha of green fodder (104 q/ha D. M.), an increase of 162% over no nitrogen treatment (115 q/ha green fodder and 37.5 q/ha D. M.). On this soil type also, split application of nitrogen had no advantage over the application of entire quantity at sowing time.

Effect of top dressing of nitrogen on fodder yield of Teosinte (Enchlaena mexicana)

The experiment was conducted for the second year. A common fertilezer does of 50 kg N/ha was given to all plots at the time of sowing and 40, 60 and 80 kg N/ha as top dressing at knee-high stage. In addition, second top dressing of 20 and 40 kg N/ha was also tried 15 days after the first top dressing on the treatments that received 40 kg N/ha at knee-high stage.

Results showed that top dressing of nitrogen significantly increased the green fodder yield. Highest green fodder yield of 372 q/ha 123.5 q/ha D. M.) was obtained with the topdressing of 80 kg N/ha at knee-high stage (61 days after sowing), an increase of 146 q/ha 52 q/ha D. M.) over basal application, 78 q/ha (29.6 q/ha D. M.) over 40 kg N/ha topdressed at knee-high stage and 55 q/ha (20.9 q/ha D.M.) over 60 kg N/ha topdressed at knee-high stage. Second topdressing of nitrogen 15 days after the knee-high stage did not result in additional yields.

Topdressing of 80 kg N/ha was fairly economical since the cost of fertilizer application was approximately Rs. 200/- per ha (@ Rs. 2.50 per kg N applied) and the value of additional green fodder yield obtained due to this treatment was Rs. 657/— per ha (green fodder was valued at Rs. 4.50 per quintal).

Comprative efficiency of (a) topdressing of nitrogen to soil, (b) foliar application of spray and fertilizer grade urea and (c) pre-emergence applicatio% of semazine on fodder yield of Sorghum (M. P. chari)

The trial was continued for the third year. All plots received a basal manuring of 60 kg N and 30 kg $P_2 O_5$/ha. Top dressing of nitrogen was done at 15 and 30 kg N/ha to soil and as foliar at boot stage. For soil application of N, fertilizer grade urea was tried, while two grades of urea (fertilizer and spray grades) were used for foliar spray. Foliar spray of 30 kg N/ha was done in two equal splits at an interval of 5 days starting from boot stage. In addition, simazine at 100, 200, 300, 400 and 500 g a. i./ha was tried as pre-emergence application to soil.

Top dressing of nitrogen to soil at 30 kg N/ha and foliar spray of spray and fertilizer grade urea at 15 kg N/ha significantly increased the green fodder yield by 49.3 q/ha (12.8 q/ha D. M.), 59.1 q/ha (19.5 q/ha D. M.) and 42.2 q/ha (15.2 q/ha D. M.) respectively over the yield of 236 q/ha (74.7 q/ha D. M.) for basal manuring. Foliar application of spray grade urea at 30 kg N/ha gave significantly higher green fodder yield of 32 5 q/ha (15 q/ha D. M.) over that obtained at 15 kg N (spray grade urea) applied at boot stage (295 q/ha green fodder and 94.2 q/ha D.M.). Simazine at 100 to 500 g a. i./ha increased significantly the green fodder yields by 56.9 to 73.8 q/ha (18.6 to 26.0 q/ha D. M.) respectively over the control yield of 236 q/ha (74.7 q/ha D. M.). However, the differences between simazine levels were statistically not significant.

Comparative merits of folior application of spray grade Vs fertilizer grade urea for fodder production of teosinte (Euchlaena mexicana)

The trial was laid cut for the second year. The crop received 50 kg N/ha basal at sowing. Foliar spray of fertilizer and spray grade urea at 40 kg N/ha was done at 60, 75 and 90 days after sowing.

Results showed that foliar spray of urea significantly increased the green fodder yield over no spray. The green fodder yield obtained by foliar spray of spray grade urea (375 q/ha green fodder and 122.2 q/ha D. M.) was 13% more than that obtained for fertilizer grade urea.

Spraying of urea at 75 days growth stage (370 q/ha green fodder and 119 q/ha D. M.) recorded higher yield than the sprayings done either at 60 days growth (349 q/ha green fodder and 112.3 q/ha D. M.) or 90 days growth (341 q/ha green fodder and 104.6 q/ha D. M.). The highest green fodder yield of 391 q/ha (131.7 q/ha D. M.) was obtained with spray grade urea applied at 75 days growth, glving a significant increase of 128 q/ha (45.4 q/ha D. M.) of green fodder over no spray; and 62 and 73 q/ha (25.3 and 31.2 q/ha D. M.). over fertilizer grade urea, sprayed respectively at 60 and 90 days growth stage.

Comparative performance of different sarson varieties sown mixed with berseem

The experiment was repeated for the second year. Three varieties of *sarson*, namely, Japan *sarson*, I. M. 98, and I. M. 100, were tried at seed rates of 1, 2 and 3 kg/ha with a view to increasing the fodder yield of berseem (diploid) in the first cut.

Results showed no significact differences in the first cut yields of berseem with the three *sasson* varieties. The yields varied from 135 to 170 q/ha (19.7 to 22.0 q/ha D. M.). Three kg/ha seed rate of *sarson* gave significantly higher green fodder yield than 1 and 2 kg/ha seed rates, the increase in green fodder yield being 14.4 and 10.1 per cent respectively over 1 kg/ha (152 q/ha green fodder) and 2 kg/ha (158 q/ha green fodder) seed rates. However, the different *sarson* varieties mixed with berseem at varying seed rates did not show any effect on the aggregate (5 cuts) yield of betseem.

Effect of nitrogen fertilization and cutting management on green and dry matter yield of M. P. chari and Sudan grass

The trial was laid out for the second year. Treatments comprised of all the combinations of (i) two crops (M. P. chari and sudan grass), (ii] two cutting management practices (cutting at 50% flowering and at dough stage) and (iii) 3 levels of nitrogen (20. 35 and 50 kg N/ha) applied after 1st cut. At sowing, all plots were fertilized with 60 kg N, 50 kg P_2O_5 and 40 kg K_2O/ha.

Results showed that M. P. chari and sudan grass were equally good for fodder production, yielding on an average 477 and 486 q/ha of green fodder (148 and 152 q/ha D. M.) respectively. Cutting of these crops at 50% flowering gave a significant increase in green fodder yield by 176 q/ha (35.7 q/ha D. M.) over that at dough stage (399 q/ha green fodder and 132 q/ha D. M.). Very poor regenration and growth was observed when the crops were cut at dough stage as compared to the cutting at 50% flowering. Application of 35 kg N/ha as top dressing after first cut increased the green fodder yield by 53.8 q/ha (27.5 q/ha D. M.) over top dressing of 20 kg N/ha. Increasing the nitrogen level of top dressing from 35 to 50 kg N/ha did not result insignificant increase either in green fodder or dry matter yields. Interactions between crops, cutting management practices and nitrogen application were not significant.

Determination of phosphate and potas requirement of lucerne

The trial was continued for the second year. The treatments were replicated five times in a split plot design with 6 phosphate levels (0, 40, 80, 120, 160 and 200 kg P_2O_5/ha) in main plots and the 3 potash levels (0, 40 and 80 kg K_2O/ha) in sub-plots. 20 kg N/ha was given basal to all plots. Lucerne variety Sirsa 9 was grown on ridges using a seed rate of 15 kg/ha. In all five cuts were taken.

Results showed that increasing levels of phosphate gave higher green fodder and dry matter yields upto 120 kg P_2O_5/ha. Application of phosphate beyond 120 kg/ha gave no additional benefit. On an average 120 kg P_2O_5 increased the yield by 305 (65.8 q D. M.), 167 (36.4 q D. M.) and 59 q/ha of green fodder (16.2 q/ha D. M.) over 0, 40 and 80 kg P_2O_5/ha treatments respectively.

Potash application resulted in significant increase in yield upto 40 kg K_2O/ha level only. This treatment increased the green fodder yield by 39.1 q/ha (8.5 q/ha D. M.) over no potash treatment (526 q/ha green matter and 109.7 q/ha D. M.). The interaction between phosphate and potas levels was not significant.

Phosphorus content of lucerne increased with increasing levels of phosphate. Phosphorus content varied from 0.193% for no phosphate

to 0.205% for 40 kg P_2O_5, 0.234% for 80 kg P_2O_5, 0.233% for 120 kg P_2O_5, 0.240% for 160 kg P_2O_5 and 0.244% for 200 kg P_2O_5/ha. Also, the phosphorus content decreased with progressive cuts and varied from 0.283% in the first cut to 0.182% in the fifth cut.

Cultural-cum-manurial trial on Guinea grass

The experiment was conducted for the first year. Split plot design was used, wherin three inter-row spacing (40, 60 and 80 cm) and three intra-row (plant to plant) spacings (20, 30 and 40 cm) kept in nine main plots and three nitrogen levels (100, 200 and 300 kg/ha) in sub-plots. In addition, all the plots received 50 kg/ha of each P_2O_5 and K_2O as a basal manuring before planting the crop. One-fifth of each nitrogen level was applied before planting the crop and the remaining was applied in four equal splits after each cut. Total of five cuts were taken.

Results showed that there was no difference between 40 cm and 60 cm row distance as their yields were 980 and 983 q/ha of green fodder (200 and 201.5 q/ha D. M), respectively. Increasing the inter-row space from 60 to 80 cm, significantly reduced the green fodder yield to 895 q/ha (183.5 q/ha D. M.). Similarly the intra-row spaces of 20 and 30 cm gave similar green fodder yields i. e. 971 and 986 q/ha (199 and 202.1 q/ha D. M.), respectively. Further increase in plant to plant distance to 40 cm resulted in considerably lower yields (901 q/ha green fodder and 184.7 q/ha D. M.).

Application of nitrogen gave linear response. On an average 300 kg N/ha increased the green fodder yields by 462 q/ha (94.7 q/ha D. M.) and 211 q/ha (43.3 q/ha D. M.) respectively over 100 kg (715 q/ha green fodder and 146.6 q/ha D. M. (and 200 kg N/ha (966 q/ha green fodder and 198 q/ha D. M.). Interactions between N-levels and spacings were not significant. Highest green fodder yield of 1317 q/ha (270 q/ha D, M.) was obtained when guinea grass was planted at a distance of 60 cm × 30 cm and fertilized with 300 kg of nitrogen/ha.

SA—3 : CROPPING PATTERNS FOR MAXIMUM FODDER PRODUCTION

(M. N. Misra, Gopichandra, N. D. Mannikar, S. N. Tripathi and H. H. Datta)

Cropping patterns for maximum fodder production per unit area per unit time

The experiment was continued for the second year. Six intensive cropping patterns were compared. Total green fodder harvested from December 1971 to November 1972 showed that the overlapping cropping system of berseem+Japan *sarson*, interplanted with hybrid napier in spring and growing of cowpea in the inter-row spaces gave the highest green fodder yield of 2599 q/ha (476 q/ha D. M.). This works out to a production of over 7.0 q/ha per day of green fodder. The other cropping patterns were in the following order: Oats–M. P. Chari Turnip (1880 q/ha green matter and 367 q/ha D. M.), berseem+Japan *sarson*–cowpea–M. P. Chari+cowpea (1662 q/ha green matter and (301 q/ha D. M.), berseem+Japan *sarson* – maize+cowpea – M. P. Chari cowpea (1638 q/ha green matter and 311 q/ha D. M.), berseem+Japan *sarson* – M. P. Chari+cowpea (1601 q/ha green matter and 305 p/ha D. M.), and oats – bajra+cowpea (1398 q/ha green matter and 319 q/ha D. M.

Growing of fodder crops in the gap period of two grain crops

Studies were undertaken to ascertain the possibility of growing suitable fodder crops in the gap period of popular cropping pattern of grain crops. The gap period of wheat – jowar rotation was selected for the study since it is the most popular rotation of the Bundelkhand region. Three fodder mixtures namely, maize+cowpea, bajra+cowpea and M. P. Chari+cowpea were grown during summer (last week of June) to test their comparative performance. It was observed that all the three mixtures tried were equally good for fodder production giving a green fodder yield ranging from 297 (M. P. Chari+cowpea) to 308 q/ha (maize+cowpea).

Maximum production potential trial

The trial was repeated for the third year. A half acre plot (0.2 hectare) was devoted to test the berseem+sarson - M. P. Chari relay sequence. Berseem (diploid) along with Japan sarson was sown on 31-10-1971 and fertilized with 20 kg N+80 kg P_2O_5/ha. Total of five cuts were taken. Bereeem gave a green fodder yield of 1140 q/ha (133 q/ha D. M.) in five cuts. Total crude protein yield was found to be 2841 kg/ha.

M. P. Chari was sown in the middle of May. 60 kg N+40 kg P_2O_5/ha was applied basal at sowing and 30 kg N/ha topdressed at 40 days after sowing, after first and 2nd cuts. Total of three cuts were taken by beginning of October and a green fodder yield of 797 q/ha (216 q/ha D, M.) was obtained. Thus a total green fodder yield of 1937 q/ha (349 q/ha D. M.) was obtained in a year with an average of 5.3 q/ha per day of green fodder.

SA—4 : SEED PRODUCTION IN FODDER COPS

(S. N. Tripathi, M. N. Misra and N. D. Mannikar)

Effect of growth retardant on the seed yield of oats

In earlier experiments with oats, application of CCC at lowest dose i. e. 2 kg a. i./ha was found to result in increased grain yield. This experiment was, therefore, initiated to determine optimum level and time of CCC application. Five levels of CCC (0.25, 0.5, 1.0, 2.0 and 4.0 kg a. i./ha) each at three times of application (45, 60 and 75 days after sowing) formed the treatments for the purpose. The crop (kent variety) was sown on 18th October 1971 and was fertilized with 50 kg N and 30 kg P_2O_5/ha. The highest yield of 33 q/ha seed was obtained with 2 kg a. i./ha of CCC which was significantly higher than other levels. Spraying of the chemical after 70 days of sowing also showed significantly higher grain yield than at other times of application. The highest seed yield of 38 0 q/ha was obtained with 2 kg a. i./ha of CCC sprayed at 75 days after sowing.

Effect of ascorbic acid on seed production of berseem

The trial was conducted for the first year. Berseem (diploid) was sown on 27th October 1971 and fertilized with 20 kg N+80 kg P_2O_5)/ ha. Three cuts were taken for fodder and thereafter the crop was left for seed production. A fodder yield of 847 q/ha was obtained in three cuts. Four concentrations of ascorbic acid (50, 100, 150 and 200 ppm) were sprayed in two frequencies (one spray-15 days after the third cutting and two sprays-15 and 25 days after the third cutting). A control (no ascorbic acid spray) treatment was also included for comparison.

Results showed that there was no significant increase in the seed yield of berseem due to ascorbic acid sprays (4.3 q/ha for no spray and 4.9 q/ha for 200 ppm ascorbic acid spray) or due to frequency of spraying (4.7 q/ha for one spray and 5.0 q/ha for two sprays). It may be pointed out that experiment was heavily damaged due to root rot disease, which appeared during the third cut of the crop.

Effect of micronutrients spray on seed production of berseem

The trial was repeated for the third year. Mn and Fe each 1.0 kg/ha, Cu and Zn each at 0.5 kg/ha, B at 0.15 kg/ha, Mo at 0,10 kg/ha and composite of all these micronutrients at concentrations mentioned were tried as foliar spray at 20 days after the third cut.

Like last year, none of the treatments were superior to the control-without spray. The seed yield varied from 473 kg (for Mn treatment) to 579 kg (for composite) per hectare. The control without spray recorded a seed yield of 508 kg per hectare. Foliar spray of Zn, B and composite increased the seed yield by 13, 27 and 71 kg per hectare respectively over that with no spray. It may be pointed out that after second cut onwards berseem plots were badly affected by some unidentified disease.

SA–5 : SOIL WATER MANAGEMENT OF FODDER CROPS
(S. B Hukkeri and N. P. Shukla)

Irrigation requirement and water use efficiency of overlapping and relay cropping for year-round green fodder production

Trial was laid out for the first year. Three cropping patterns (berseem+sarson—napier+cowpea; berseem+sarson M. P. chari+ cowpea; and oats—cowpea—M. P. chari+cowpea) were tested under three levels of soil moisture regimes (25, 50 and 75% ASM).

The results indicated that the green fodder yield increased significantly from 1135 q/ha (217.3 q/ha D. M.) for irrigation at 25% ASM to 1305 q/ha (248.5 q/ha D. M. for) 50% ASM. The yield difference between 50% ASM and 75% ASM was, however, not significant.

Overlaping cropping of berseem+sarson—napier+cowpea had given higher yield (1459 q/ha green fodder and 271.4 q/ha D. M. than the relay cropping (1382 q/ha green fodder and 258.5 q/ha D. M.) of berseem+Japan sarson--M. P. chari+cowpea and 989 q/ha green fodder (194.3 q/ha D. M.) for oats—cowpea—M. P. chari+cowpea. The interaction of irrigation and cropping petterns was not significant.

Effect of levels of soil moisture, nitrogen, phosphorus and potash on the fodder yield of turnip

The trial was conducted for the first year. Three levels of soil moisture (25, 50 and 75 percent ASM), three levels of nitrogen (30, 60 and 90 kg N/ha), three levels of phosphorus (0, 30 and 60 kg P_2O_5/ha) and three levels of potash (0, 30 and 60 kg K_2O/ha) were tried in 3^4 confounded factorial design in 9 blocks of 9 plots each. Sowing was done on 22nd October 1971 in rows 30 cm apart. Harvesting of green fodder was done on 5th January 1972.

Result showed that application of 60 kg P_2O_5/ha increased the fresh fodder yield of turnip (both leaf+root) significantly by 162 q/ha over control (no application of phosphorus) yield of 445 q/ha and 137 q/ha over 30 kg P_2O_5/ha. Among the different interactions, only phosphorus × potashinteraction was found significant. Application of 60

kg P_2O_5/ha with 30 kg K_2O/ha recorded significantly higher yield (673 q/ha). The effects of different levels of irrigation, nitrogen and potash on fodder yield were not significant.

Effect of levels of soil moisture, plant density and nitrogen on the forage yield of hybrid napier

The trial was continued for the third year with a view to studying the effects of soil moisture(irrigation at 25, 50 and 75% ASM), plant density (27777, 41666 and 55555 hills/ha)and nitrogen application after each cut (at 40, 80 and 120 kg N/ha) on the forage yield of hybrid napier (variety Hybrid No 1). Four cuttings were taken during May to November.

The results indicated that the green fodder yield of 759 q/ha D. M.) for irrigation at 25% ASM increased significantly to 879 q/ha (116.2 q/ha D M.) for irrigation at 50% ASM. Further increase in moisture level was of no added advantage. The plant densities tried had no significant effect on forage. Significant yield response was obtained upto 120 kg N/ha (after each cut), recording a maximum green fodder yield of 1054 q/ha (140.5 q/ha D. M.). None of the interactions was significant.

Effect of soil moisture stress at different stages of growth on the forage yield of M. P. Chari *(Sorghum bicolor)*

Trial was repeated for the second year and sown on 3rd April, 1972. The crop was cut for fodder on 17-6-1972 at 50% flowering.

The results revealed that like last year, irrigation at optimum level (control) gave the maximum yield (270 q/ha) and stress at establishment (0-30 days after sowing), elongation (31-55 days) and primordial (55-75 days) stages reduced the green fodder yield by 21, 23 and 16 percent, respectively. Stress during both elongation and primordial stages reduced the yield by 53 percent but the yield of the crop when it was subject to stress at establishment and primordial stage was as good as the stress at elongation stage. Irrigation at sub optium level (F. C. to 50% ASM) during establishment stage and then at optimum level till 50 percent flowering showed only 6% reduction in in yield over control, but there was much reduction in yield (36%) when the soil moisture was sub optimum at both the stages i. e. establishment and elongation stages.

Effect of soil moisture stress at different stages of growth on seed yield of berseem

This was the first year of the experiment. Crop was sown on 28.10.1971. Upto third cutting for fodder, all the plots received irrigation at optimum level (75% ASM). After third cutting for fodder on 24.2.1972, the stress treatments were imposed by withholding irrigation at different stages of crop growth and the yields were compared with control (no stress at any stage after the third cut i. e. 4 irrigations at 15 days interval).

The results revealed that the seed yield was significantly affected by different stress treatments. The maximum seed yield of 6.04 q/ha was obtained by the application of two irrigation 15 and 30 days after 3rd cutting of crop for fodder, followed by 5.78 q/ha when these two irrigations were applied just after and 30 days after 3rd cutting. The control yield was 4.46 q/ha. Thus, it was seen that the application at flowering (30 days growth) alongwith one irrigation just after or 15 days after the 3rd cutting was sufficient for higher seed production in berseem.

Effect of soil moisture stress at different stages of growth on seed yield af oats

This was the first year of the experiment. Crop was sown on 23.10.1971 and soil moisture stress was imposed by withholding irrigations at different stages of crop growth i. e. irrigation at tillering, late tllering, jointing, flowering, milk and dough. The yields were compared with the control which was not irrigated throughout the growth period. The crop was harvested for seed on 4.4.1972. The maximum seed yield of 36.4 q/ha was recorded when oat crop was irrigated at all the critical growth staged as mentioned above. The increase in yield over control (15.7 qh/a) was 132%. It was observed that irrigations at late tillering and flowering stages were very important for seed production in oats. Imposition of moisture stress by withholding irrigations at these two critical growth stages severely reduced the seed yields.

SA-6 : AVAILABILITY AND UPTAKE OF NUTRIENTS
(N. D. Mannikar and S. N. Tripathi)

Effect of sulphur on fodder and seed yield of ber eem

A trial was conducted for the first year to study the effect of S on fodder and seed yield of berseem. The treatments comprised of control (with no S and no P), single and triple superphosphate each at 40, 80 and 120 kg P_2O_5/ha; and also triple superphosphate (TSP) at the rate of 40, 80 and 120 kg P_2O_5/ha in combination with 25, 50 and 75 kg S (as Calcium sulphate) per hectare. Basal appiication of 20 kg N/ha was given uniformly to all the plots. Three cuts were taken for fodder and then the crop was left for seed setting.

The data on aggregate yield of three cuts on green and dry matter indicated that the treatment differences were not significant. The green fodder yield varied from 649 q/ha for control to 725 q/ha for 120 kg P_2O_5 as TSP+50 kg S as Calcium sulphate/ha. The corresponding dry matter yields were 87.83 and 90.39 q/ha respectively. The chemical analysis of soil samplee from the experimental plots indicated high available phosphate content (187 kg P_2O_5/ha). It may also be mentioned here that severe plant damage was observed due to some unidentified disease after second cut onwards.

There were no significant differences in seed yields which ranged from 414 to 550 kg/ha.

Research contemplat d

In addition to the technical programme of 1972, in general, the following new research work will be undertaken :

1. Soil test-crop response in fodder crops.
2. Evaluation of indigenous rockphosphates for their fertilizer value.
3. Characterisation of different soil types in forage growing areas.
4. Tissue testing in fodder crops.
5. Irrigation and N-requirements of *Pennisetum pedicellatum*.

GRASSLAND MANAGEMENT DIVISION

Salient features

Primary production studies in *Chrysopogon* grasslands revealed that the highest production of litter (294 g/m^2) was obtained in February. The aboveground biomass showed a peak production of 216 g/m^2 in September. The belowground biomass in the same period was 497 g/m^2. The corresponding figures in *Iseilema* grasslands were 132 and 290 g/m^2 for above-and belowground biomass, respectively. The litter production was negligble except in March when dry matter production was 38.7 g/m^2.

Application of nitrogenous fertizer to *Heteropogon* grasslands showed a linear response upto 20 kg N/ha, resulting in the highest dry matter yield of 72.5 q/ha.

Stylosanthes humilis showed best establishment (21000 plants per ha) in the treatment of pre-monsoon dibbling in *Sehima* grasslands. In the case of *S. gracilis* line sowing treatment in monsoon and an application of 20 kg P_2O_5/ha recorded the best performance (13300 plants per ha).

The grass seed germination varied with species, period of storage, temperature and moisture stress. Thus the seeds of *Sehima nervosum* stored for sixteen months showed highest germination at alternating temprature of 32°C and 18°C at a moisture stress of 5-7 atmospheres. seeds of *Cenchrus ciliaris, C. setigerus, Dichanthium annulatum* and *Chrysopogon fulvus* (Mhow) stored for two years recorded highest germination at 32°C.

The seeds of *Acacia tortilis* and *Leucaena leucocephala* showed optimum germination when treated with concentrated sulphuric acid for 50 minutes.

Sixty days cutting regime at 30 cm height and high density sowing (31666 plants/ha) resulted in a phenomenal dry matter yield of 132 q/ha in *Leucaena leucocephala.*

Burning, annually, biennially, or triennially, followed by grazing increased the percentage composition of *Heteropogon contortus* but decreased that of *Sehima nervosum.*

In the silvipastoral studies, *Cenchrus ciliaris* showed good compatability and combining ability with fodder trees *Leucaena leucocephala* spaced 4 × 4m and *Acacia tortilis* (4 × 6 m) which brought an extra yield of 42.9 q/ha and 41.9 q/ha respectively of dry grass in addition to the fodder/fuel from the trees.

RESEARCH WORK DONE

GM–1 : GRASSLAND PRODUCTIVITY

1.1 : Primary production, energy relations and nutrient circulation in grasslands of Sehima-Dichanthium cover.
(Vinod Shankar)

Chrysopogon fulvus grassland

Monthly observations on aboveground (green and dry) and underground biomass as well as litter production were taken during the one year cycle from June 1971 to May 1972. Litter production in June was 208 g/m^2. After showing a decline from July through November, the litter production increased to 236 g/m^2 in December.

The highest figure of litter production was, however, in February (294 g/m^2). The underground biomass reached the peak production in September (497 g/m^2) followed by that of December (371 g/m^2). The highest underground biomass was, however, recorded in the month of January (511 g/m^2). The aboveground biomass (green) showed the highest production for the season in August (432 g/m^2). The production showed a decline from October to June. Aboveground biomass (dry) varied very little (216 to 231 g/m^2) from June to September, whereafter it declined to 72 g/m^2 in November. The highest (421 g/m^2) dry standing crop was observed in January.

Iseilema laxum grassland

The period and nature of observations in *Iseilema* grassland were same as for C. *fulvus*. The litter production was of a very low order as

compared to that in C. *fulvus*. Very little fluctuation occurred from June 17.4 g/m^2) to November (13.5 g/m^2). There was, however, gradual increase from December (52.8 g/m^2) onwards and it reached the highest figure (387.0 g/m^2) in March. The litter biomass showed decline during April and May. The trends in seasonal variation in the above and underground standing crop were nearly the same pattern as obtained in C. *fulvus* grassland. The highest figure for the underground biomass was obtained in September (290 g/m^2). In the same period, the aboveground biomass (green) also showed the highest peak (388 g/m^2) but thereafter, a downward trend followed as in the case of C. *fulvus* grassland. Dry standing crop of *Iseilema* grasslands showed similar trend as in C. *fulvus* upto January when it was 185g/m^2 After showing a decrease to 77 g/m^2, in Februruary, it again attained the maximum of 202 g/m^2 in April.

1.2-1 : Effect of nitrogen and phosphorus on production and quality of principal grass communities of Sehima-Dichanthium grasslands (Ravi Kumar and K. A. Shankarnarayan)

Heteropogon grass lands

The experiment was continued for the third year. The treatments consisted of all the combinations of three levels of nitrogen (30, 60 and 90 kg N/ha) and three levels of phosphorus (30, 60 and 90 kg P_2O_5/ha).

Results showed that increasing the level of application of nitrogen from 30 to 90 kg/ha resulted in linear increase in the dry grass yield of *Heteropogon* grassland. The production of dry forage increased from 45.3 q/ha with 30 kg N/ha to 72.5 q/ha with application of 90 kg N/ha. Similar increase in the level of P_2O_5 application had no effect. The nitrogen × phosphorus interaction was not significant.

Sehima grasslands

The trial of nitrogen and phosphorus on *Sehima* grasslands was initiated during the year with four levels of nitrogen (30, 60, 90 and 120 kg N/ha) and three levels of phosphorus (30, 60 and 90 kg P_2O_5/ha.)

Results showed that in *Sehima* grasslands also, there was a linear response to the application of nitrogen. The dry grass yield increased from 36.0 q/ha with 30 kg N/ha to 78.3 q/ha with the application of 120 kg N/ha. There was no response to application of phosphorus in these grasslands.

1.2-3 : Effect of nitrogen and phosphorus on production and quality of herbage in Cenchrus setigerus

(Ravi Kumar and K. A. Shankarnarayan)

The experiment was continued for the fourth year. The treatments consisted of all combinations of four levels of nitrogen (0, 30, 60 and 90 kg N/ha) and three levels of phosphorus (0, 30 and 60 kg P_2O_5/ha).

Results showed that application of nitrogen to *Cenchrus setigerus* pasture resulted in linear increase in yields upto 90 kg/ha. The highest yield of 36 q/ha was recorded with application of 90 kg N/ha. Applicatian of phosphorus showed progressive increase in yields upto 60 kg P_2O_5/ha. The interaction between nitrogen and phosphorus was significant. Phosphorus application (60 kg P_2O_5/ha) in the absence of nitrogen application gave the highest response of 25.6q/ha dry forage Further, significant response to phosphorus application was observed only upto 30 kg P_2O_5/ha when given in combination with 60 or 90 kg N/ha. Though the highest dry matter yield (39.6 q/ha) was obtained with the combination of 90 kg N+60 kg P_2O_5/ha, this yield was not significantly higher than that with 90 kg N+30 kg P_2O_5/ha (38.1 q/ha).

The low overall dry matter yields in *Cenchrus setigerus* (four year old stand) is noteworthy. Notwithstanding the drought that prevailed during the year, the leftover stubble of previous years became very woody and this seems to have impeded fresh tillering during the year resulting in loss of vigour and productivity. Thinning or burning, as a management practice, in the fourth year, is considered essential to rejuvenate the *Cenchrus* pastures.

1.2–4 : Effect of nitrogen and phosphorus on the production and quality of herbage in Cenchrus ciliaris

(Ravi Kumar and K. A. Shankarnarayan)

The experiment was continued for the fourth year. The treatments consisted of all conmbination of four levels of nitrogen (0, 30, 60 and 90 kg N/ha) and three levels of phosphorus (0, 30 and 60 kg P_2O_5/ha).

Application of nitrogen to *Cenchrus ciliaris* grasslands showed significant response upto 90 kg N/ha. The dry matter yield was raised from 17 q/ha in control to 56 q/ha with application of 90 kg N/ha. Application of phosphate, however, had no effect on the yield of this grass. The interaction of nitrogen x phosphate was also not significant.

1.4–1 : Effect of the application of varying doses of phosphate and varying intervals of cutting on growth and forage production of tropical pasture legumes

(P. K. Jayan, K. C. Velayudhan and K. A. Shankarnarayan)

The experiment was initiated during the year to study the effect of levels of phosphorus (0, 30, and 60 kg P_2O_5/ha (including split application to soil and foliar spray) and inlervals of cutting (4, 8 and 16 weeks) on the growth and production of four pasture legumes viz: *Phaseolus atropurpurus, Stylosanthes humilis, Clitoria ternatea* and *Atylosia scarabaeoides,* which were established during the year. The treatment will be imposed in 1973 *kharif.*

GM–2 : GRASSLAND IMPROVEMENT

2.1 : To find out a suitable technique for the establishment of promising legumes in natural grasslands

(P. K. Jayan, K. C. Velayudhan and K. A. Shankarnarayan)

The experiment was initiated during the year with a view to studying suitable techniques for the establishment of *Stylosanthes humilis* and *Stylosanthes gracilis* in *Sehima* grasslands. There were seven cultural treatments of which three were pre-monsoon and four monsoon treatments. The former comprised of broadcasting with and without harrowing and dibbling while the latter consisted of broadcasting with or without harrowing and line sowing with or without fertilization (20 kg P_2O_5/ha).

Dibbling of seeds in premonsoon showed the highest plant establishment (21,000 plants/ha) in *Stylosanthes humilis*. The treatment involving line sowing in monsoon and application of 20 kg P_2O_5 appears best for establishment of *Stylosanthes gracilis* (13,300 plant/ha).

GM–3 : GRASSLAND UTILIZTION

3.1 : Relative grazing values of principal grass species of Sehima-Dichanthium cover

(K. A. Shankarnarayan, A. K. Dabadghao and P. M. Dabadghao)

The experiment was continued for the fourth year. Grazing using Mandya sheep (five each) commenced on 28th August in the paddocks of *Cenchrus setigerus*, *C. ciliaris Sehima nervosum*. Fixed stocking rate was practised by adjusting the grazing period with forage availability. Thus, sheep were withdrawn from paddocks of *Cenchrus setigerus* and *C. ciliaris* on 1st December, while those in *Sehima nervosum* were withdrawn on 16th October 1972.

The initial average weights of sheep were 32.4, 30.0 and 34.1 kg respectively before their entry into the paddocks of above mentioned grasslands. The performance of sheep from 24-8-1972 to 1-12-1972 is presented in the following Table.

Performance of seep in grasslands of *C. ciliaris*, *C. setigerus* and *S. nervosum*

Date	Average body weight of sheep in kg.		
	Cenchrus setigerus	C. ciliaris	Sehima nervosum
24-8-72	32.4	30.0	34.1
15-9-72	32.8	29.9	34.7
16-10-72	32.4	30.2	33.4
16-11-72	34.1	30.1	—
1-12-72	30.9	28.2	—

Results showed that the body weight of sheep was maintained till 16th October in *Cenchrus setigerus*. Thereafter, it steadily increased and the sheep recorded an average body weight gain of 1.7 kg on 16th November. However, the animals began losing weight thereafter and were, therefore, withdrawn from grazing on 1st December.

In *Cenchrus ciliaris*, the animals maintained their body weight upto 16th November and thereafter lost their weight steadily as in the case of *Cenchrus setigerus* and were, therefore, withdrawn from paddocks on 1st December, 1972.

The performance of sheep in *Sehima nervosum* paddock showed an increase of 0.6 kg on 15th September (21 days). Thereafter, the animals began losing weight steadily. The performance of *Sehima* was, thus, of a very low order as compared to *Cenchrus setigerus* or *Cenchrus ciliaris*. The tall habit of *Sehima nervosum* and its low leaf-stem ratio are reckoned as possible causes for the poor sheep performance.

GM—4 : RANGE ECOLOGY

4.3 : **Study of plant succession in grasslands on rocky substratum in Sehima community**

(B. K. Trivedi, Vinod Shankar and K. C. Kanodia)

The experiment was continued for the fifth year to study the plant succession on rock outcrop under natural conditions. An exclosure of barbed wire followed with chicken wire upto 30 cm height from ground level was provided to protect the vegetation. The succession was studied through permanent line transects on crevices and permanent list and denuded quadrats. Observations revealed the following trends in succession.

Plant succession in crevices of the rock outcrop

Chrysopogon fulvus and *Tephrosia villosa* attained increasing dominance, while *Indigofera cordifolia, Borreria stricta, Oropetium thomaeum, Melanocenchris jacquemontii* and *Alysicarpus* sp. became intimately associated with these dominants.

Plant succession at the base of rock outcrop

Observations were recorded in denuded and list quadrats. The vegetation complex developed with passage of time contributed to the building up of the soil. The habitat so built up appeared conducive for the appearance of the species higher in ecological succession. The following eight stages were recognised in the succession.

1 Sedge stage *(Cyperus uncinatus* and *Fimbristylis diphylla)*
2 *Fimbristylis diphylla—Oropetium thomaeum*
3 *Oropetium thcmaeum—Eragrostis viscosa*
4 *Oropetium thomaeum—Melanocenchris jacquemontii*
5 *Melanocenchris jacquemontii—Aristida sp.*
6 *Eragrostiella bifaria*
7 *Heteropogon contortus* (annual)
8 *Heteropogon contortus—Sehima nervosum*

4.3—1 : **Study of moisture regine in grassland soils and its effect on growth and yield of grasses**

(Vinod Shankar and N. P. Shukla)

Sehima narvosum grasslands

Monthly observations were carried out from 23-8-1972 to 23-12-1972 on the soil moisture content at various depths (0-15 cm to 90-120 cm) in *Sehima* grasslands with a view to studying their effects on growth and dry matter production of grass. Results showed that soil moisture decreased from August (10.0 per cent) to December (1.6 per cent). The soil moisture also showed variation at different depths each month. For example in August, the soil moisture increased with depth upto 30–45 cm showing a maximum of 12.5 per cent but thereafter decreased to 8.6 per cent at 90-120 cm depth. During September to December, the values of soil moisture at 0-15 and 90-120 cm debth varied from 6.9 to 10.2, 2.1 to 8.1, 2.3 to 3.8 and 1.9 to 4.1 per cent respectively showing thereby an increase in soil moisture with depth. Moreover, the difference in soil moisture with depth was most pronounced in themonth of October. The total dry grass production during the season amounted to 18.4 q/ha.

Heteropogon grasslands

Monthly observations on soil moisture at various depths (0–15 to 90–120 cm) were also carried out in *Heteropogon* grassland in the same periods as in *Sehima* grassland. Results showed that the percentage of soil moisture increased from August (7.5 per cent) to September (9.2 per cent). It began to decrease gradually thereafter till December when the soil moisture was 1.8 per cent. Like *Sehima* grasslands, the highest soil moisture was recorded at 30–45 cm depth in August. During September, it varied from 6,8 to 10.4, 2.5 to 12.1, 2.6 to 5.3 and 1.4 to 4.4 per cent at 0–15 and 90–120 cm depth. Like *Sehima* grasslands, the variability in soil moisture was most pronounced in October. The dry forage yield in the season was 17.9 q/ha.

4.4 : **Autecology of grassland species**
(P. S. Pathak and R. Deb Roy)

Effect of temperature on germination of grass seed

Germination of grasses was tested at 32°C, 25°C and 32°C, 18°C temperatures, Sixteen months stored seeds of *Dichanthium annulatum* (36.0), *Sehima nervosum* (32.0), *Bothriochloa pertusa* (11.2) and *Dactyloctenium aeqyptium* (31.2) showed better germination at alternating temperature. *Cenchrus ciliaris* (26.6), *Chrysopogon fulvus* (Mhow) (45.2), *Heteropogon contortus*(78.0), *Melanocenchris jacquemontii* (26.0) and *Themeda quadrivalvis* (77.2) showed optimum germination at 32°C. The corresponding temprature for *Chrysogogon fulvus* (Chandigarh strain) (50) and *Pennisetum pedicellatum* (40,0) was 25°C. seeds of *Dichanthium annulatum* (7.3), *Cenchrus ciliaris* (24.6), *Sehima nervosum* (16.6) *Chrysopogon fulvus* (5.0), *Bothriochloa pertusa* (7.3), *Eragrostiella bifaria* (13.3), *Melanocenchris jacquemontii* (58.6) and *Iseilema laxum* (18.0) after four months dry storage gave slightly better germination at 32°C.

Effect of moisture stress on grass seed germination

Seeds of *Chrysopogon fulvus*, *Sehima nervosum* and *Dichanthium annulatum* of different collection years were tried for germination at 0, 0.33, 5.0, 7.5, 10.0. 12.5 and 15.0 atmospheres of misture stress. The *Chrysopogon fulvus* seeds of 1970 collection gave better germination

than those of 1969 and maximum at zero atmospheres (42%). In *Sehima nervosum* 1970 collection showed better germination than those of 1971 and maximum was obtained at 5.0 atmospheres (26%). Seeds of *Dichanthium annulatum* of 1970 collection gave better germination at all the stress conditions, the maximum being at zero atmospheres (37.3%).

Effect of ripening date on germination at different temperatures in Sesbania species

In *Sesbania grandiflora* and *Sesbania microcarpa*, sixteen months stored seeds of October ripening showed better germination at 32°C than at 25°C, but those collected in October or December and stored for only one month had better germination at 25°C. Seeds of *S. aegyptiaca* stored for one or sixteen months showed better germination at 32°C.

Germination of fodder tree seeds

Studies on seeds of *Leucaena leucocephala* were completed and those of *Acacia tortilis* were tested for germination. From a seed lot, 5 types were delineated on the basis of their size and weight. The seed weight ranged from 45.6 to 94.2 mg from smaller to bigger size.

To break the testa dormancy, the seeds were treated with sulphuric acid for 0, 5, 10, 15, 30, 40, 50 and 60 minutes and kept for germination at 35°C in the germinator. Seeds without scarification did not germinate. Maximum germination (58%) was obtained in the seeds treated for 30, 40 and 50 minutes.

Seeds scarified for 50 minutes duration were sown in soil at different depths (0, 1, 2, 4, 6 and 10 cm). The seeds sown at 1 cm depth gave highest seedling emergence of 74%.

Dry matter production of L. leucocephala sown at different densities and subjected to three intervals and intensities of cutting

Plants sown in three replicates at 31666, 18333 and 11666 plants/ha densities were cut after 4 months of growth in July at 10, 20 and 30 cm height from the ground level. The intervals of cutting were fixed at 40, 60 and 120 days thus giving 4, 3 and 2 harvests upto December,

1972. Maximum dry matter production (132 q/ha) was obtained in the first density type at 30 cm clipping height and 63 days interval of cutting followed by 104 q/ha in the same density type at 20 cm height and 40 days of cutting interval. The lowest production of 32 q/ha was obtained in the second density type clipped at 20 cm height and 120 days interval. Fresh weight and leaf dry matter followed similar pattern. Cutting after 120 days resulted in early flowering and fruiting due to which the leaf dry weight was reduced.

4.5-1 : Effect of frequency of burning with or without grazing on changes in the botanical composition in Sehima grasslands

(B. K. Trivedi, Vinod Shankar and K. C. Kanodia)

The experiment was continued for the fifth year, with the 8 treatments-no burning, burning annually, biennialiy and triennially each with or without grazing (50 per cent grazing regime). Burning treatment was imposed in the 3rd week of January 1972 as per schedule. The following results were obtained.

Changes in the botanical composition of Sehima grasslands

Burning generally promoted the stands of *Heteropogon contortus* The percentage composition recorded was 23.7, 36.3, 31.8 and 30.4 for the years 1969, 1970, 1971 and 1972, respectively. The corresponding figures for *Sehima nervosum* were 38.4, 39.5, 27.8 and 28.6, respectively indicating that burning was not favourable for *Sehima nervosum.*

In the beginning, grazing generally promoted *Sehima nervosum* but it did not favour *Heterogogon contortus.* However, the trend became reversed in the third and fourth year. Thus the percentage composition of *Sehima nervosum* was 61.3, 74.4, 48.3 and 39.2 and that of *Heteropogon contortus* was 5.1, 1.6, 8.5 and 12.5 for each of the 4 consecutive years, respectively.

Annual burning combined with moderate grazing showed a continuous decrease in the percentage composition of *H. contortus* while in the case of *S. nervosum,* there was an initial increase followed by decreasing trend.

Burning every second year combined with moderate grazing increased the percentage composition of *Heteropogon contortus* from 17,3 to 23.3 in 4 years whereas the same treatment showed gradual decrease in the persentege composition of *Sehima nervosum.*

Buring every third year combined with moderate grazing revealed that the composition of *Heteropogon conturtus* showed anoverall increase, whereas that of *Sehima nervosum* showed a steady decrease.

Change in vigour and tussock count

There was no radical change in the vigour and tussock counts in both *Heteropogon contortus* and *Sehima nervosum.*

GM–5 : FOREST GRAZING – APPRAISAL, PRODUCTION AND UTILIZATION

5.1 : Evaluation of forest grazing resources in tropical dry deciduous forest grasslands

(R. Deb Roy and P. S. Pathak)

The studies initiated during 1970 in Bundelkhand Forest Division were continued during the year with a view to finding out the grazing resources of the different forest areas for formulation of management practices consistent with the silvicultural needs of the trees for getting optimum forage production, in addition to production of timber and fuelwood.

Evaluation of forest grassland resources were carried out in five forest ranges viz: Madaura, Lalitpur, Jhansi, Talbehat and Gursarai during the year.

Results showed that the highest forage production of 643 kg/ha was obtained from Amodahadda Coupe II of Madaura range. The other coupes in descending order of production were Thangara coupe I (607 kg/ha), Lakhanjar coupe I (554 kg/ha) of Madaura range; Bhashney coupe II (525 kg/ha) of Gursarai range and Dhukhwa coupe IV (511 kg/ha) of Jhansi range. The lowest forage production of 93 kg/ha was recorded in Daurisagar coupe II of Madaura range. The low forage production is perhaps attributable to high incidence of bush cover which hampered the growth of grasses. Forage production in general was higher in teak working circle compared to miscellaneous working circle. Similar results were obtained in the last two years also

but the magnitude of dry forage production was greater in 1970 (1728 kg/ha) and 1971 (1533 kg/ha). The principal cause for successive decrease in the forage production is ascribed to heavy grazing and disappearance of the perennial grasses from the coupes which are supposedly protected from the incidence of grazing for optimum regeneration of trees.

5.2 : Silvipastoral studies on the establishment and growth of plantation species in an integrated land use pattern

(R. Dev Roy and P. S. Pathak)

The experiment was continued during the year to study the establishment and growth of fodder trees alongwith grasses and also to find out a suitable tree-grass combination for optimum production and stock carrying capacity of forest grassland. The treatment consisted of all combinations of two spacings (4m × 4m, 4m × 6m), 2 fodder trees species (*Acacia tortilis, Leucaena leucocephala*) and three seedings (no seeding, seeding with *Cenchrus ciliaris* and seeding with *C. setigerus*). The grass crop was harvested in September.

Results showed that *Cenchrus ciliaris* gave a higher forage production as compared to *Cenchrus setigerus* in all the treatments. Highest forage production of 42.9 q/ha of *C, ciliaris* was obtained in the treatment involving *Leucaena leucocephala* seedlings at closer spacing. In the case of *Acacia tortilis*, forage pryduction from *Cenchrus ciliaris* was higher (41.9 q/ha) with wider spacing as compared to 32.2 q/ha in closer spacing treatment. However, in *C. setigerus* highest yield was 29.6 q/ha in wider spacing.

In all these treatments *Acacia tortilis* showed cent per cent survival. But in *Leucaena leucocephala*, the survival percentage varied from 75.0 to 94.4 per cent. The height increment of *L. leucocephala* could not be assessed as the seedings were subjected to biotic interference. Maximum annual height increment of 82.4 cm was recorded in *A. trotilis* with wider spacing under no grass treatment. Minimum height increment of 44.4 cm was shown in the closer spacing under *C. settgerus*,

It could be concluded, therefore, that apart from the yield obtained from the fuel cum fodder trees, it is also possible to derive an extra dry forage yield of 43 q/ha through proper silvipastoral management.

Silvicultural studies

Out of the 22 species of fodder trees introduced during last year, three species viz., *Albizzia amara, Acacta tortilis* and *Acacia arabica* continued to exhibit cent per cent survival. Their descending order of ranking were *Hardwickia binata, Leucaena leucocephala, Prosopis cineraria, Dalbergia sissoo* and *Azadirachta indica* with 92.3, 84.6, 80.8, 80.8, and 77.0 per cent survival respectively. Cutting of *Morus alba* failed to survive. *Albizzia amara* showed maximum height of 220 cm followed by 204, 179 and 141 cm respectively in *Acacia tortilis, Acacia arabica* and *Zizyphus spinachristi.* Highest annual height increment of 103 cm was recorded in *Albizzia amara* followed by 92, 90, 86 and 47 cm respectively in *Acacia tortilis. Zizyphus spinachristt, Acacta arabica* and *Hardwickia btnata.* The lowest height increment (10 cm) was recorded in *Prosopis cineraria.*

During the year under report, 13 more species were introduced in the arboretum. Of these, four species, *Glyricida maculata, Bauhinia purpurea, Albizzia richardiana* and *Pongamta pinnata* showed cent per cent survival. The survival percentage in *Albizzia mollisima* was the lowest (46.7).

Research contemplated

1. Studies on comparative economics of arable farming versus grassland farming,
2. Comprative study of effect of different sources of nitrogenous fertilizer and farm yard manure on production and quality of *Sehima-Dichanthium* grasslands.
3. Comparative evaluation of set stocking and rotational grazing systems of grasslands for pasture and lamb production.

4. Effect of closure on botanical composition of high altitude temperate grasslands.
5. Effect of NPK on temperate pastures on production and quality of temperate grasslands.
6. Introduction of clovers in the temperate grasslands.
7. Re seeding of temperate grasslands with perennial rye grass S–23, S–24 and *Lolium multiflorum.*
8. Comparative study of continuous versus deferred rotational grazing in temperate grasslands

WEED ECOLOGY AND CONTROL DIVISION

Salient feature

Kharif weed survey was conducted in the eastern zone, and 237 specimens have been collected for the weed herbarium. Autecological studies of two noxious weeds, *Parthenium hysterophorus* and *Cyperus rotundus*, indicated high seed production (3500 seeds/plant and 1380–2000 seeds/plant, respectively) and viability (98%) in the former. In *C. rotundus*, fluctuating temperatures promoted germination. Crop-weed interaction studies in fodder sorghum, led to the conclusion that weed control could be best done at the early growth stage of the crop,

Attempts are also underway to standardize the chemical control measures in respect of exotic weed *Parthenium histerophorus* L. Foliar spray of diuron or atrazine at $M \times 10^{-6}$ appeared to act as an antitranspirant resulting in increased grain yield inwheat and improved harvest index. Ammonium sulphamate has indicated potentials for brush control in grasslands. *Benz–meth–carbamate* and *meto–bromuron* appeared to be well tolerated by six rabi crops. *ABP 68-64* gave good promise for enhancement of berseem seed yields through bioregulation. Differential tolerance for atrazine was indicated in fodder sorghum varieties, M. P. Chari, J. S. 20 and Swarna. Alachlor was promising in okra-wheat rotations.

Sensitive methods for determination of diuron and cotoran have been developed for detection of residues in fodder crop produce. Alachlor or *Nitralin* used for weed control in soyabean did not alter the quality constituents. Atrazine treated fodder sorghum did not cause any health hazard in rabbits.

Application of atrazine herbicide upto 2.0 kg a. i./ha does not affect the physico-chemical properties of the soil. While available N in soil was increased from 0.5 to 2.0 kg ai/ha, there was no consistent trend in P availability.

RESEARCH WORK DONE

WE—1 : SURVEY AND COLLECTION OF WEEDS

1.1 Autecology of weeds

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

The study envisaged autecology of various weeds so as to locate vulnerable points in their life cycles for their control. During the year, the noxius exotic weed *Parthenium hysterophorus* L. was studied. The weed preferred moist, shady habitats rich in soil organic matter. It was observed that the plant was a prolific seed-producer. A single plant produced Ca. 3500 seeds. Flowering was hastened in open, dry situations but the seeds of this weed are viable. Scarification as well as temperatures ranging from 15-40°C increased the seed germination. The steeped-water of the seeds depressed the germination of other seeds e. g. *Echinochloa colonum.*

The nutsedge *(Cyperus rotundus* L.*)* plant has a very high reproductive potential and produced Ca. 1380-2000 seeds/plant. Its seeds failed to germinate at constant temperatures of 10, 20 and 30°C. Only 8 per cent seeds germinated when the temperature varied between 10-30°C in 7-17 hours cycles. However, the seedings failed to establish.

The relative dry matter production (d. m.) rates (g/day) were studied in four weeds viz., *Asphodelus tenuifolius* (0.174), *Medicago denticulata* (0.156), *Convolvulus arvensis* (0.069) and *Melilotus alba* (0.057) which indicated the competitiveness of these weeds.

1.2 Regional weed survey, collection and mapping

(S. R. Gupta)

Survey, collection and mapping of weeds was undertaken in areas of Ranchi, Cuttack, Bhubaneshwer, Barrackpore and Kalyani of

eastern zone, representing different agroclimatic regions, for ascertaining infestations of *kharif* weeds. The studies were made separately in (i) cultivated fields, (ii) waste lands and fallow fields and (iii) ruderals. In the case of paddy fields floristic composition of weeds in the uplands, medium and lowlands as well as deep aquatic weeds were studied. 237 weed specimens have been collected and processed for preservation in the herbarium. Of these 124 were from the paddy fields, 66 were emergent and marshy habitat weeds. The phytosociological and community complex studies are underway.

1.3 Studies on crop weed interactions

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

An experiment was laid out in *kharif* to study the crop weed interactions and the extent of competition with weeds in the M. P. chari fodder crop. Fourteen paired plots, were sown with M. P. chari and in each of the paired plots, one plot, selected at random, was kept weed free. The chief weeds observed in the crop were *Echinochloa colonum, Dactyloctenium aegyptium, Phyllanthus niruri, Cyperus rotundus* and *Stenophyllus barbata.* Cuts for fodder were taken twice, first at grand period of growth and second at mature stage of the crop. It was observed that the weed infestation was maximum during the grand period of crop growth and was reduced as the crop matured. The losses due to competition at grand period of growth were 24.5 per cent and at maturity 19.9 percent. Hence the best period of weed control in this crop appears to be at the early crop establishment stage.

WE-2 : STRUCTURE—ACTIVITY RELATIONSHIP AND SELECTIVITY OF HERBICIDES

(T. R. Datta and J. N. Gupta)

Sixh erbicides, each at three levels, were tried for their selectivity on six crops (oat, barley, wheat, mustard, gram and linseed) in two replications. *Benzmeth carbamate* pre-planting, was tolerated by all crops upto 3 kg a. i./ha. Pre-emergent Benzmeth-carbamate (granular and liquid) and Metobromuron were tolerated by all crops upto 2 kg a. i./ha. All crops were susceptible to chlorothiamid pre-emergent at

the lowest dose of 0.75 kg a. i./ha. In post-emergent treatments of mecoprop and dichloroprops epinastic effects were observed on leguminous weeds as well as on some crops viz., mustard, linseed and gram, while these had no adverse effects on wheat, oat and barley at the lowest dose 1 kg a. i./ha. TQ-2 (a new Japanese herbicide) was tolerated by all crops upto 4 kg a. i./ha. The effects af this herbicide were not apparent on *rabi* weeds.

Attempts are also being made for the standardization of the chemical control measures in respect of exotic weed *Parthenium hysterophorus* L.

Bio-regulation with herbicides

A code numbered chemical *(ACP 68-64)* was used at three low non-lethal doses of 0.5, 1.0 and 1.5 kg a. i./ha along with control (no chemical) as foliar spray on berseem at the flowering stage for inducing enhanced seed yields. With the increase in the dose of the chemical beyond 0.5 kg a. i,/ha, the berseem seed yield decreased from 285 to 200 kg/ha. Application of this chemical at the lowest dose of 0.5 kg a. i./ha resulted in an increase of 51 kg/ha seed yield over the control yield of 234 kg/ha showing promise for enhancing berseem seed production through bio-regulation with herbicides. Further trial for synergistic effects with phosphate treatment are underway.

Three substituted urea herbicides and two triazine compounds were screened, for affecting partial closure of stomata each at very low non-lethal doses viz. $M \times 10^{-6}, ^{-9}.^{-12}$, as foliar spray along with a control (no herbicide) on wheat *cv* K 65 grown under non-irrigated conditions. It was observed that diuron or atrazine at $M \times 10^{-6}$ were very effective in causing partial closure of stomata and reducing transpiration without affecting photosynthesis. This resulted in increased grain yields and improved harvest index. The grain yields varied from 141 g/m^2 in control to 211 g/m^2 in Diuron $M \times 10^{-6}$ treated plots and the harvest index from 0.40 for control to 0.93 for the application of Diuron at $M \times 10^{6}$. Simazine at $M \times 10^{-6}$

also showed promise and gave grain yields of 202 g/m² and harvest index of 0.74 These herbicides probably hold promise in dryland agriculture.

As a preliminary study, four herbicides each at two doses were evaluated for groundnut and guar crops. Among them, Nitralin and Alachlor gave promising results. For paddy crop, fiive herbicides each at two doses were tried Molinate and Sirmate were found promising.

Preliminary trials for the control of six different brush species viz., *Carissa spinarum*, *Acacia catechu Butea monosperma*, *Zizyphus nummularia*, *Z. rotundifolia* and *Lantana camara* with the use of *Tandex (NTA 11092)* and Ammonium sulphamate were carried out Ammonium sulphamate as foliar spray has given good results.

WE-3 : WEED CONTROL AS AN INPUT FOR HIGHER PRODUCTIVITY IN FODDER CROP ROTATIONS

(R. P. Singh and R. K. Pandey)

With a view to studying the effect of weed control on the productivity in fodder ratations, trials were conducted. The results obtained in trials with different crops are as follows :

Mustard :

In this trial pre-emergence treatments of Nitralin (0.75 and 1,50 kg a. i./ha) Nitrofen (1.5 and 3.0 kg a. i./ha) and Amiben (1.5 and 3.0 kg a. i./ha) were tried along with hand weeding and control (no treatment) treatments using a randomised block design. Amiben at 3.0 kg a. i./ha gave the highest seed (mustard) yield of 7.1 q/ha which was 2.7 q higher than that due to the hand weeding treatment. This was followed by 6.6 q/ha due to Nitralin(1.5 kg a. i./ha) and 6.2 q/ha due to Nitrofen (3.0 kg a. i./ha) treatments. Weed control using higher doses of the weedicides resulted in higher seed yields.

Lentil

With a view to determining the efficacy of weed control treatments in combination with phosphorus application (0 and 40 kg P_2O_5/ha) to lentil crop, an experiment was conducted using pre-

emergence applications of RH 315, *Linuron* and *chlorobromuron* each at two levels (0.5 and 1.0 kg a. i./ha) along with hand weeding and control (no treatments.)

Application of P_2O_5 at 40 kg/ha had no added advantage in the grain yield of Lentil. Though the weedicide application treatments gave higher yields than control (no treatment), their yields were at *par* with that due to the hand weeding treatment. The application of *Chlorobromuron* and *Linuron* each at 0.5 kg a. i./ha with grain yield of 28.0 and 27.2 q/ha respectively appeared promising over control and hand weeding treatments (22.0 and 25.1 q/ha grain respectively).

Soybean-wheat

With a view to studying the residual effect of weedicide applied for control of weeds in Soybean crop wheat crop was grown in the subsequent *rabi* season. Each treated plot of Soyabean was divided into three sub-plots for application of treatments (preemergence application of *Chlorobromuron* @ 0.75 kg a. i. and 2), 4-D amine @ 0.75 kg a. i./ha along with control–no treatment) for the control of weeds in the wheat crop (vriety Sarbati sonora).

The yield of wheat was higher in the hand weeded Soyabean plots (50.9 q/ha) followed by Soyabean plots treated with *Chlorobromuron* @ 1.5 kg a. i./ha (45.6 q/ha) and *Monsanto* 099 @ 1.0 kg a. i./ha (43.3 q/ha). The untreated (control) plots of Soybean yielde. 37.7 q/ha of wheat. Application of *Chlorobromuron* @ 0.75 kg a. i./ha to the wheat crop resulted in an average increase of 9 2 q/ha of wheat.

Okra-wheat

There were no adverse residual effects of the weed control treatments given to the Okra crop on the subsequent crop of wheat, during the first year of the experiment. The experiment was repeated during *kharif* 1972. The weedicide *Pebulate* was dropped and the experiment was continued with two doses of *Alachlor* (2.0 and 4.0 kg a. i./ha), *Amiben* (1.5 and 3.0 kg a. i./ha), *Prometryne* (1.0 and 2.0 kg a. i./ha) and *Nitrofen* (1.5 and 3.0 kg a. i./ha) along with hand weeding

and control (no treatment), as treatments. Pusa Sawani variety of Bhindi was used for the experiment.

Except for the weedicide *Amiben* (both doses) others have given significantly higher yields than that obtained under hand weeding (11.12 q/ha). The control (no treatment) yield was 7.5 q/ha. The highest yield of 62.62 q/ha was obtained from plots treated with *Alachlor* @ 2.0 kg a. i./ha followed by 50.98 q/ha from Prometryne (2.0 kg a. i./ha) treated plots.

Cotton

A preliminary trial to study the effect of weed control in cotton crop was laid out. Pre-emergence application of *Prometryne* (1.0 and 2.0 kg a. i./ha) and *Linuron* (0.5 and 1.0 kg a. i./ha) and pre-planting soil incorporation of *Nttralin* (0.5 and 1.0 kg a. i./ha) along with control (no treatment) were evaluated.

The weedicides *Prometryne* and *Nitralin* were found promosing in controlling both broad leaf and grass weeds.

Fodder Sorghum

The fodder varietis M, P. chari, JS 20 and grain variety Swarna were assessed for their tolerance to *atrazine*. Four doses 0, 0.5, 1.0 and 1.5 kg a. i./ha of *atrazine* were tried. M. P. chari and JS 20 tolerated upto 1 kg/ha of *atrazine*. In Swarna, yield was reduced drastically even at 0.5 kg/ha due to phytoxicity.

An experiment was initiated with fodder sorghum M. P. chari using the combinations of dates of sowing, hot weather cultivation, nitrogen doses and herbicide application as treatments adopting a split plot design. The treatments were combinations of the factors viz., (i) ploughing (no ploughing, deep ploughing), (ii) Nitrogen (40 and 80 kg N/ha), (iii) dates of sowing (1st, 15th and 30th July) and (iv) pre-emergence application of *atrazine* (0.0 and 1.0 kg a. i./ha). It appeared that the herbicide had the maximum effect on the crop sown on 1st July. In the late sowings, weed competition was less. The fodder yield was better with 80 kg N/ha.

WE-4 : FATE OF HERBICIDES IN PLANTS AND THEIR INTERACTIONS

(R- K. Gupta and T. R. Dutta)

(a) *Diuron residues* : A colorimetric method based on hydrolysis of diuron followed by diazotization of the resulting 3, 4–dichloroaniline and coupling with alkaline β–naphthol has been developed for the determination of diuron residues in lucerne and fodder sorghum *cv.* M. P. chari. The method is simple, accurate and sensitive up to 1 ppm.

(b) *Cotoron residues* : A method for estimation of *cotoran* (herbicide recommended for cotton, sunflower, maize, sorghum and sugarcane etc.) has been standardised. The method is based on the acid hydrolysis of the herbicide cotoron and colorimetric estimation of the resulting 1.1, 1–trifluoromethyl aniline. The aromatic amine was diazotized and coupled with alkaline β–naphthol. The resulting red dye was estimated colorimetrically at 540 mu.

(c) Soybean

(R. K. Gupta, T. R. Dutta, A. K. Srivastava and O. P. S. Panwar)

Soyabean seed samples (from a weed control demonstration trial at Nagpur) were analysed for their total protein, carbohydrate, fatty oils, phospholipids, Ca, N, P and amino-acid constituents. The materials were further fractionated for globulin and albumin. No appreciable changes in the chemical constituents were observed in the soyabean seed as a result of alachlor and nitralin herbicide application.

WE-5 : EVALUATION OF HERBICIDE TOXICITY ON ANIMALS

(A. K. Srivastava and J. Prasad)

The studies were conducted with atrazine (at 1 kg a. i./ha) treated fodder sorghum *cv.* M. P. chari. The health, general appearance, reproductive and mating behaviour of the treated fodder-fed animals remained unaltered compared to untreated control, It was observed that the herbicide treated fodders were safe for feeding to rabbits.

WE-6 : NUTRIENTS AVAILABILITY AND UPTAKE AS AFFECTED BY HERBICIDE APPLICATION

(O. P. S. Panwar)

An experiment was conducted during *Kharif* season on *Sorghum bicolor* Cv. M. P. chari to study the effects of herbicide application on dry matter production (yield), soil fertility and nutrient uptake by the crop. The treatments were pre-emergence application of atrazine at 0.5, 1.0 and 2.0 kg ai/ha. along with weed-free and unweeded-controls. The crop was harvested at three stages viz., seedling, fllowering and maturity. Plant samples from each harvest were collected for nutient (N, P, K) analysis. Soil samples were collected from 0-15 cm and 15-30 cm depth before the application of treatments and after the harvest of the crop, and were analysed for their physico-chemical characteristics (viz. pH, electrical conductivity, organic Carbon, Ca Co3 and texture) and available N & P nutrients.

The application of atrazine at 0.5 kg a. i./ha gave highest dry matter yield 136 q/ha as against 128 q/ha in control). The application of atrazine at 2.0 kg ai/ha produced depressing effect on the dry matter yield (117 q/ha) due to crop mortality. The physico-chemical properties of the soil (such as pH, Electrical Conductivity, Organic Carbon, CaCo3 and texture) were not affected by herbicide application. With the increase in herbicide rate of application from 0.5 to 1.0 & 2.0 kg ai/ha the availablc N was increased (265.4, 296 2 kg/ha as against 254.8 kg/ha of control). No difinate trend could be observed in relation to available P. However, no adverse effect of herbicide treatment on P availability was noticed.

Research contemplated —

1. Selectivity of new herbicides for their potentials under Indian conditions.
2. Advance evaluation of weed control methods for small farmers, holdings, c and farming, forage based crop rotations including food, horticultural and commercial crops, forest grazinz areas, water courses and fishery lakes etc.

3. Assessment of herbicides as regulants for physiological functions and their compatibility with pesticides, fertilizers, adjuvants, synergists etc.
4. Studies on weed flora of various agro-climatic regions, weed migration, autecology and biological control.
5. Studies on absorption, translocation, mobility and degradation of herbicides.
6. Investigations on storage life of herbicides, residue, tolerance limits in plants, animals and soil. Studies on crop quality as affected by herbicide application.
7. Assessment of application machinery, mechanical weed control, effect of droplet size, ultra low volume spray etc.
8. Demonstration of improved weed control methods in various crops.

PLANT ANIMAL RELATIONSHIP DIVISION

Salient features

Oat varieties 2688, fulgham and 3008 were found promising due to their high crude protein yield when cut at 50% bloom stage, but no significant differences were obtained among the 15 multicut varieties tested. Application of 120 kg nitrogen and 60 kg P_2O_5 yielded maximum quantity of crude protein in oat (860 kg/ha). Both *in vitro* and *in vivo* studies showed that digestibility co-efficient of all the constituents of fodder oat decreased with advancing stages of maturity. A positive nitrogen balance was found when Barbari bucks were fed on oat fodder, at all stages of crop growth but not at the regrowth. Nutritive value of fodder oat (at boot stage) conserved as hay was superior to silage.

Lucerne varieties, I. L. O.-67-258, Hissar and selection I were found promising on account of their high crude protein yield. Application of 120 kg P_2O_5 and 40 kg K_2O/ha in lucerne gave maximum crude protein yield (2603 kg/ha).

Studies on the effect of soil moisture stress on the HCN content of summer-grown M. P. chari revealed that in the absence of soil moisture stress during the first 32 days of crop growth, the 42 days old crop can be safely fed while moisture stress during this period rendered the crop unsafe (due to high HCN content) for animal consumption until the 52nd day. The digestibility co-efficient of dry matter, D. C. P. and T. D. N. values of M. P. chari were found to be 57.4%, 2.3% and 55.3% and that of cowpea were 65.1%, 10.4% and 64.7% respectively on Haryana bullocks.

Trial on individual *Vs* group feeding showed that dry matter intake from berseem hay and body weight gain in group fed animals were more than that in individually fed Barbari kids. In feeding experiments with *Leucaena leucocephala,* it was found that Barbari bucks which had a higher intake showed a tendency of alopacia.

It was found that concentrate supplementation was not necessary if the kids were provided with good quality grass-legume pasture.

For hay-making in berseem, fence method of Jhansi was found to be highly economical over chaff method. The quality of product (hay) was also markedly superior in the fence method though slightly higher losses in dry matter and protein during hay-making were recorded in this method as compared to chaff method.

RESEARCH WORK DONE

PAR-8 : EVALUATION OF FORAGE CROPS IN RELATION TO LIVESTOCK PRODUCTION.

1.1 : **Studies on the chemical evaluation of forage crops for nutrient yield, possible phytotoxic and other physiologically active constituents**

(A. P. Singh and S. C. Gupta)

Effect of soil moisture stress on the hydrocyanic acid content of M. P. chari at the different stages of growth

The experiment was conducted in collaboration with Soil Water Management Section of the Soil Science and Agronomy Division on medium black clay-loam soil to find out the effect of soil moisture stress on hydrocyanic acid content of summer sown M. P. chari at different stages of crop growth. The soil moisture stress treatments were i) S_0 – No stress, ii) S_1 – Stress in the first 32 days of growth, iii) S_2 – Stress from 33rd to 55th day of growth iv) S_3 – Optimum irrigation during the first 32 days growth and sub-optimum irrigation during the rest of the growth. v) S_4 – Sub-optimum irrigation during the first 32 days growth and optimum irrigation during the rest of the growth period and vi) S_5 – Sub-optimum irrigation throughout the growth period.

The M. P. chari crop harvested at 22nd day of its growth under all the six tretments showed very high HCN content (1450 to 1890 ppm on dry matter basis), whereas when the harvesting was delayed upto its 32nd day of growth there was steep fall in the HCN content under all the treatments and varied from 410 to 950 ppm on dry matter

basis. Further delaying of the harvesting upto 42nd day of its growth showed further fall in the HCN content which was lower than the toxic level of 250 ppm on dry matter basis under all the soil moisture stress treatments except for S_1. The HCN content under S_1 for crop harvested on 42nd day of its growth was significantly higher than those under other treatments. When the crop was harvested at 52nd day of growth the HCN content under S_1 also fell below the toxic level. Thus, it is seen that M. P. chari grown in summer season under soil moisture stress for a longer period in establishment stage (i. e. S_1 treatment) cannot be fed to cattle before 52 days of growth. However, with certain irrigation and water management practices it appears that the crop can be made safe for feeding to cattle even at 42 days' growth.

Chemical composition of oat varieties

The trials were laid out by Plant Improvement Division of the Institute.

(a) Single cut

From a varietal trial with 15 varieties of oat (single cut) harvested at 50% flowering stage, samples were collected for the estimation of chemical composition. The percent crude protein in the samples varied from 6.5 to 9.3 percent and the estimated yield of crude protien of these varieties were between 472 and 736 kg/ha. There were no significant differences between the varieties tested in respect of their percentage content and yield of crude protein, How ever varieties 2688, fulgham and 3008 appeared to be promising on account of their estimated high crude protein yields (736, 733 and 711 kg per ha, respectively).

(b) Multicut

15 varieties of oat (multicut) were grown in three replications using randomised block design. Samples from the two cuts taken (first cut, 80 days after sowing and second cut, 50 days after the first cut) were analysed for their crude protein and neutral detergent fibre contents. The pooled data for the two cuts indicated that these strains did not differ significantly in respect of their crude protein content and yield. The range was from 9.2 to 12.2 percent and 449 to 730 kg/ha for

crude protein content and yield, respectively. Neutral detergent fibre content and its yield varied from 42 4 to 57.2 per cent and 18.4 to 42.2 q/ha, respectively. The top varieties in the order of their crude protein yields were 2705, 2681, FOS 1/29, 2660, 2672 and 3008, with the yields of 730, 728, 670, 659, 628 and 597 kg/ha However, the varieties 2672, 2681, 2660 and 2705 had higher NDF contents varying between 55.6 to 57.2%. The variety FOS 1/29 appeared to be promising because of its low NDF content (42.4%). The variety 3008 was also promising with low NDF content (46.5%).

Chemical composition of lucerne varieties

Samples were analysed for chemical composition from a trial with 12 varieties of lucerne, laid out by Plant Improvement Division of the Institute. In all, four cuts were taken. Crude protein and neutral detergent fibre were estimated. The weighted average of per cent of crude protein and neutural detergent fibre of varieties varied from 17.9 to 21,5 percent and 36 5 to 42.6 per cent respectively. The results suggested that varieties I. L. O.-67-272, I.-L.-O.-67-258, Hissar and Selection I were promising on account of their higher crude protein yields, i. e., 2732, 2657, 2580 and 2526 kg/ha respectively. The lowest yield of crude protein (1989 kg/ha) was given by Anand-2 variety.

Fertilizer response on the chemical composition of oats and lucerne

These trials were conduc'ed by Soil Science and Agronomy Division of the Institute.

(a) Varietal trial on oat under different levels of nitrogen and phosphorus.

3 varieties of oats (E. C. 13044, E. C. 13594 and Kent) with 3 levels of P (O, 30, 60 kg P_2O_5/ha) and 4 levels of N (0, 40, 80 and 120 kg N/ha) were grown, using split plot design (varieties and P in main plots and N in sub-plots) in 3 replications. The fodder was harvested 110 days after sowing. Crude protein and neutral detergent fibre contents were estimated.

There were no significant differences in respect of the crude protein per cent (5.6 to 6.0), crude protein yield (536-613 kg/ha) and neutral detergent fibre yield (52.4 to 55.3 q/ha) between the varieties tested.

Use of increased levels of P fertilizer slightly increased the crude protein yield from 527 to 606 kg/ha. The NDF yield of 59.5 q/ha obtained with the application of 60 kg P_2O_5/ha was significantly higher by 11.3 and 6.6 q/ha than that over the application of 0 and 30 kg P_2O_5/ha respectively.

Increased levels of N application significantly increased the crude protein percent from 4.7 to 6.8, crude protein yield from 326 to 800 kg/ha and neutral detergent fibre yield from 36.1 to 70.1 q/ha.

Application of 120 kg N alongwith 60 kg P_2O_5 gave the highest crude protein yield of 860 kg/ha. However, the yield of 824 kg/ha of crude protein obtained by lowering the dose of P_2O_5 to 30 kg/ha was not significantly lower.

(b) Phosphate and potash requirements of lucerne

Six levels of phosphorus (0, 40, 80, 120, 160 and 200 kg P_2O_5/ ha) and 3 levels of potassium (0, 40 and 80 kg K_2O/ha), were tried on the lucerne crop using a split plot design (P in main plots and K in sub plots) with five replicates. In all, five cuts were taken in 217 days. Fodder samples were analysed for crude protein and neutral detergent fibre.

Application of neither phosphorus nor potash was found to have effect on the overall crude protein and neutral detergent fibre contents of the lucerne crop. However, total yields of crude protein and neutral detergent fibre increased from 1331 to 2409 and from 2729 to 5180 kg/ ha respectively with the application. of P_2O_5 at 120 kg/ha. Further increase in the level of phosphorus application was found to be of no added advantage. Similarly, application of 40 kg K_2O increased the crude protein and neutral detergent fibre yield to 2162 kg and 4540 kg/ha respectively from 1970 kg and 4039 kg/ha respectively when no K fertizer was applied.

Application of 120 kg P_2O_5 and 40 kg K_2O/ha gave the maximum crude protein yield of 2603 kg/ha.

1.2 : IN VITRO STUDIES ON THE DIGESTIBILITY OF IMPORTANT FODDERS AND FORAGE CROPS

(S. C. Gupta and A. Rakib)

Quality of fodder oat as affected by stage of growth/cut, and conservation practices

Samples of fodder oat (Kent) pertaining to various digestibility *-cum-*metabolism trials (*vide* Project No. 1.3) were evaluated for *in vitro* true dry matter digestibility' (IVTDMD) contents. The results indicated that the *in vitro* digestibility of 'refused' feed (from each animal) was slightly lower than that of the corresponding feed 'offered' during each study Thus, IVTDMD values on the basis of actually ingested feed were calculated.

The results showed a progressive decline in quality of oat fodder with advancing maturity. The IVTDMD values for early boot, boot, 10 percent flowering, milk and dough stages of growth were found to be 94.1, 91.9, 78.4, 71.9 and 67.8 per cent respectively. The mean results (calculated on the basis of *actually* ingested feed), on the other hand, showed that the quality of fodder oat was the best at early boot and boot stages (94.4 and 93.8 per cent). This value came down to 79.9 and 80.9 per cent at 10 per cent flowering and milk stages and further declined at dough stage (74.1 per cent). When the fodder oat was again harvested 65 days after the first cut (taken at early boot stage), the corresponding results were found to be 76.5 end 81.9 percent respectively.

The IVTDMD valves, obtained on the basis of feed offered and when it was actually ingested in the case of fodder oat as green (harvested after 87 days of sowing i, e. boot stage) and as hay and silage, were 91.9 and 93.8 per cent; 86.7 and 87.9 per cent; and 83.9 and 85,1 per cent respectively. This indicated that the quality of fodder oat was slightly affected by both the conservation methods, and greater deterioration was noticed when oat fodder was conserved as silage.

1.3 : STUDIES ON THE NUTRITIVE VALUE OF IMPORTANT FODDERS AND FORAGE CROPS FOR BUFFALO, CATTLE AND GOAT

(N. C. Verma, A. P. Singh, A. Rekib, V. S. Upadhyay and P. S. Pathak)

Studies on the nutritive value of oat var. kent at different stages of growth.

Australian-Kent variety of oat was sown in a plot (0.5 ha) on 23rd October, 1971. The seed rate of the crop sown was 100 kg/ha. Ammonium sulphate and calcium ammonium nitrate fertilizers were applied in split doses to provide 50 kg Nitrogen/ha.

The fodder was harvested according to the following schedule :

(i) 70 days after sowing (pre-boot stage), (ii) 87 days after sowing (boot stage), (iii) 107 days after sowing (10% flowering), (iv) 148 days after sowing (milk stage), (v) 170 days after sowing (dough stage) and (vi) 65 days after 1st cut at the pre-boot stage (regrowth).

Digestibility-cum-metabolism trials were conducted by feeding chaffed fodder *ad lib* on three yearling Barbari bucks with oat fodder, harvested as per above schedule.

Chemical composition and yield

The maximum dry matter yield (69.6 kg/day/ha) was obtained at dough stage followed by milk stage (69.0 kg/day/ha). The dry matter yield was lowest (38.8 kg/ha/day) at pre-boot stage. The content of crude protein (%) in the fodder decreased progressively from 16.8 at the pre-boot stage to 7.0 at dough stage. The lowest crude protein content (5.3 per cent) was found in regrowth (second cut) samples. The total yield of crude protein was maximum at milk stage (878 kg/ha) followed by dough stage (829 kg/ha). The per day production of crude protein was maximum at pre-boot stage (6.51 kg/ha) followed by milk stage (5.93 kg/ha). Both total yield (145 kg/ha) as well as per day yield (2.27 kg/ha) was lowest for the regrowth.

Dry matter consumption

The dry matter consumption af oat in Barbari bucks varied from 3.26 to 3.42 kg/100 kg body weight from pre-boot to 10% flowering stage, but at milk and dough stages the dry matter consumption decreased significantly (2.21 and 2.35 kg/100 kg body weight respectively). The consumption of dry matter was 2.66 kg/100 kg body weight of goats for second cut oat fodder.

Nutritive value

The digestibility of dry matter for oat fodder harvested at milk stage was significantly lower than that at other stages of growth.

There were no significant differences between fodder samples harvested at the pre-boot, boot, 10% flowering and dough stages of growth in respect of crude protein digestibility, while significantly low crude protein digestibility was noticed at milk stage as compared to the above stages of growth. Crude protein digestibilities for milk stage and regrowth samples were very low and were of the same order.

Digestible crude protein content (13 per cent) at pre-boot stage was significantly higher than that at other stages. There was little difference between 10% flowering and milk stages of growth in respect of DCP content. DCP (6.1 per cent) obtained at dough stage was significantly lower than at pre-boot and boot stages but did not differ significantly with the 10% flowering and milk stages. Very low DCP (3.1 percent) was obtained at regrowth (second cut). Total digestible nutrients (TDN) did not vary significantly except at milk stage, at which it was significantly lower than at other stages of growth.

Nutrient yield

The DCP yield varied from 353 to 765 kg/ha for the first cut samples, the maximum being at milk stage. 84.8 kg/ha DCP was obtained at regrowth. The yield of TDN varied from 2135 to 9105 kg/ha through pre-boot to dough stages of maturity. The maximum yield of TDN was obtained at dough stage.

Balances

Nitrogen balances were found positive in all the physiological stages of groth of oat fodder except at regrowth where it was negative (-2.53 g.) The retention of nitrogen was very high (+ 7.06 g) at the early boot stage and low at milk stage (+0.87 g). A positive calcium balance was obtained in all the stage except at early boot and boot stage. As the stages of maturity advanced the calcium balance increased. Positive phosphorus balances were also obtained in all the stages except at early boot and milk stages.

Studies on chemical composition and nutritive value of oat (green), oat (silage) & oat (hay)

To study the comparative nutritive value of the three forms of oat fodder, viz., green fodder, hay and silage, digestibility-cum-metabolism trials were conducted on yearling Barbari bucks. Green oat fodder was harvested daily at the boot stage from the field and fed to Barbari bucks after chaffing.

Oat fodder at t he boot stage was conserved as hay and silage. Silage was prepared by chaffing the green fodder wilted to 45 per cent dry matter and ensiled in drums. The silo was opened after 40 days.

Ch mical composition

The chemical composition of three physical forms of oat fodder i. e. green, ay and silage has been presented in Table–1. Per cent contents of crude fat & NFE were lower, while crude fibre content was higher in hay than in green and silage.

Palatability

It was found that ani mals consumed 4.62, 3.42 and 2.34 kg of dry matter per 100 kg body weight from oat hay, green & silage respectively. Thi: ndicated that oat hay was highly palatable, while oat silage was least palatable.

Table—1. Chemical composition of oat fodder as green, hay & silage (per cent content on dry matter basis).

Type of Fodder	Dry matter	Crude protein	Crude fat	Crude fibre	N.F.E.	N.D.F.	Ash	Ca	P
Green oat	19.7	10.1	2.9	20.3	58.8	39.6	6.9	0.26	0.13
Oat hay	83.0	10.9	1.9	31.5	44.3	53.0	10.9	0.32	0.14
Oat silage	45.8	10.2	2.6	21.6	54.1	47.0	11.4	0.36	0.13

Digestibility-cum-balance studies

The *in vivo* and *in vitro* digestibility of the dry matter is lowered by silage making. Similarly, the digestibility of the crude protein in the silage was lower by about 18.5 and 22.0 per cent than that of green and hay respectively.

The content of digestibile crude protein (DCP) was higher in hay (9.0 per cent) than green (8,0 per cent), while it was the lowest in silage (7.1 per cent). The retention of nitrogen was almost double inhay as compared to green and was 4 times more than that of silage.

Studies on nutritive values of M. P. chari and cowpea

A digestion trial was conducted on six Haryana bullocks by feeding M. P. chari and cowpea, harvested at milk and 50 per cent flowering stages of growth, respectively.

Chemical composition, nutritive value and digestibility co-efficient of dry matter of these crops have been presented in Table 2 and 3. Dry matter intake of M. P chari was 1.73 kg per 100 kg body weight. The digestibility co- efficient of dry matter, D.C.P. and T.D.N. values of this crop were found to be 57.4, 2.3 and 55.3 per cent respectively.

Table—2. Chemical composition of M. P. chari and Cowpea (percent on dry matter basis)

Fodder	D. M.%	Total Ash%	C. P.%	C. F.%	E. E.%	N.E.F.%	O. M.%
M. P. Chari	36.5	9.1	5.2	34.8	1.50	49.3	90.9
Cowpea	29.8	8.5	14.7	29.2	2.50	45.1	91.5

Table—3. Digestibility co-efficients and digestible nutrients of M. P. chari and Cowpea

Feed	D. M. intake per 100 kg body weight (kg)	D. M. intake per unit metabolic size (g)	Digestibility co-efficients						Digestible nutrients	
			O.M.	C.P.	E.E.	C.F.	N.F.E.	D.M	D.C.P.%	T.D N.%
M.P. chari	1.78	78.9	59.7	39.3	57.2	54.5	65.4	57.4	2.28	55.3
Cowpea	2.38	105.9	68.7	70.8	48.1	49.7	81.0	65.8	10.40	64.7

Chemical composition and nutritive value of Leucaena leucocephala

The purpose of this study was to investigate the effects of feeding of *Leucaena leucocephala* on the animal health and to find out the digestibility values of its nutrients. Keeping above in view, a feeding, digestibility-cum-metabolic trial was conducted in collaboration with the Forest Grazing Section of the Grassland Management Division. *Leucaena leucocephala* leaves were fed to four Barbari bucks. The animals were kept only on tree leaves. Feeding trial was conducted for thirty three days from 11th July to 12th August, 1972 and digestibility-cum-metabolic trial was conducted from 6th to 12th August, 1972.

The leaves contained 34.3, 21.4, 6.5 and 8.3 per cent D. M., crude protein, other extract and total ash respectively. The average dry matter intake was 2.16 kg per 100 kg body weight. The animal, whose intake was maximum, showed tendency of *alopacia* during the last week of the experimental period. During 33 days of feeding trial, body weight lose of 55 g/head/day was recorded. The dry matter and organic matter digestibility was 71.4 and 74.3 per cent respectively

Comparative study ef individual Vs group feeding on intake of berseem hay by goat.

The purpose of this study was to compare the voluntary intake of roughage (berseem hay) when the animals were fed individually and in group. The experiment was conducted for six weeks with mature Barbari bucks. It was found that the intake of berseem hay was more in group fed animals (2.51 kg per 100 kg body weight) than that of the individually fed animals (2.03 kg per 100 kg body weight). It was also noted that the intake of any increased from 1st to 2nd week (1.50 kg to 1.94 kg in individual and 2.06 kg to 2.26 kg in the case of group fed animals) and from 2nd to 3rd week period (to 2.40 kg and 2.60 kg in individual and group fed animals respectively) after which no substantial increase was found. There was gain in body weight of group fed animals (+0.5 kg) where as the individually fed animals lost their body weight (0.4 kg) during the 6 weeks experimental period,

PAR—2 : STUDIES ON THE ECONOMIC USE OF FODDER FOR INCREASED LIVESTOCK PRODUCTION

2.1 : Studies on the production potential of different forages in terms of quantity and quality of goat meat.

(A. K. Dabadghao, V. S. Upadhyay & A. Rekib)

Present study was undertaken to determine the effect of concentrate supplementation on the quality and quantity of meat when the kids were provided with good quality pasture, a combination of Pusa Giant Anjan grass *(Cenchrus ciliaris)* and Siratro legume *(Phaseolus atropurpureus)*. Barbari male, uncastrated kids of 7-8 month old, were divided into three groups and fed concentrate mixture according to the following schedule-group A (no concentrate), group B (175 gm) and group C (90 gm concentrate mixture/head/day). Half and 1/4th nutrient requirement as recommended by Morrison was met from above two levels of concentrate supplementation, respectively. The concentrate mixture was prepared by mixing 98 parts crushed barley and 2 parts supermindif mineral mixture. The animals were allowed to graze the pasture daily from 8.00 A. M. to 4.00 P. M.

A digestion trial was conducted after 60 days of grazing to determine the intake and digestibility of the grazed herbage.

It was found that average body weight gains per animal per day was 42.3, 44.2 and 38.5 g in group A, B and C, respectively. The average intake of pasture was estimated to 2.45, 1.64 and 2.59 kg per 100 kg body weight in groups A, B and C, respectively following direct mouth collection method of Rama Murthy and Talapatra (1968). Forage consumed by the animals of group A, B and C contained 5.65, 6.42 and 6.21 per cent digestible crude protein and 61.94, 58 64 and 60.62 per cent TDN, respectively.

Average moisture percentages in fore and hind limbs and lumbar region were 76.0, 70.3, 77.8 in group A; 80.7, 28.6, 83.8 in group B and 83.4, 84.9, 85.9 in group C, respectively. The average protein percentages in fore and hind limbs and lumbar region were 17.4, 19.1, 18.3 in group A; 22.0, 23.2, 22.8 in group B and 20.4, 21.8, 20.8 in

group C, respectively. The average fat percentages in fore and hind limbs and lumbar region was 4.35, 5.30, 1.65 in group A; 5.85, 7.35 and 4.00 in group B and 5.00, 5.60, 2.80 in group C respectively.

The results indicated that concentrate supplementation was not necessary if kids were provided with good quality grass legume pasture.

PAR—3 : STUDIES ON CONSERVATION OF FODDERS AND FORAGE CROPS

(A. K. Dabadghao, Mahipal Singh and A. Rekib)

Comparative study in making berseem hay

A comparative study of making berseem hay in three different cuts were made by three methods. viz., ground, fence and chaffed methods. The nutrient losses during hay making and the economics of preparing hay were also worked out. It was found that in the fence and ground methods the percentages of dry matter loss were 10.6 and 11.5 respectively, while it was minimum 9.8 per cent in chaffed method of Hissar. Similarly, the loss of protein was lower in chaffed method (12.4 per cent) as compared to ground and fence method (17.0 and 13.5 per cent respectively).

Although there were slightly less nutrient losses in chaffed method, the cost of hay making by this method was more (Rs. 3.60/q) and more than three times higher than that of the fence method (Rs. 1.20/q) and ground method (98 paise/q).

The hay prepared by fence mathod (Jhansi) was found to possess green colour and pleasant aroma, while hay prepared by chaffed method turned black in colour possibly due to the enzymatic reaction occuring during drying of the chaffed fodder.

PAR—4 : STUDIES ON THE METABOLISM OF FARM ANIMALS BY FEEDING FODDERS AND FORAGE CROPS

4.3 : Studies on rumen metabolism and possible microbial changes in rumen by feeding different levels of herbicides/herbicide treated fodders and forage crops

(J. Prasad, A. K. Dabadghao, R. P. Singh and A. Rekib)

Effect of Atrazine treated M. P. chari on the rumen microbes and rumen metabolism in buffalo

Two fistulated, male buffaloes were used for this study. One

was fed with Atrazine (1.0 kg a. i./ha) treated M. P. chari while the other was given untreated fodder. The period from 6th September to 21st September, 1972 was pre-experimental and from 22nd September to 6th October, 1972 was the experimental period. Rumen samples were collected, before feeding and watering, daily for the first three days and then on alternate days during the experimental period. In the rumen liquor of the animal fed on Atrazine treated fodder only slight increase in rumen pH (7.0 to 7.3), ammonia nitrogen (18.6 to 24.3 mg/100 ml) and fall in total bacterial count ($24\ 8 \times 10^9$ to 18.2×10^9/ ml RL) was observed. The other parameters in this animal as well as all the parameters in the other animal remained more or less constant.

Effect of prolonged administration of Hostacycline on rumen metabolism in goat

This study was undertaken in fistulated goat to study the effect of prolonged intra ruminal administration of 10 mg Hostacycline/kg body weight on rumen metabolism, disease susecptibility, body weight and allied clinical symptoms. The antibiotic was administered daily from 3rd May to 3rd June, 1972 before feeding and watering of the animal. It was found that there was slight increase in ruminal pH (6.60 to 6 83) ammonia–N (16.1 to 19.1) and protozoal number (44.3 to 49.3×10^4 mg/100 ml) while there was fall in the concentration of total volatile fatty acid (77.86 to 66.80 meg/litre) of the rumen liquor due to the adminstration of Hostacycline. An increase body weight from 24.53 to 26 25 kg during the period of the experiment was also recorded. Rumen movements were less forceful and transient anorexia was observed in early days of experimentation.

Research contemplated

1 Intensification of the work on establishment and standardisation of the two-stage *in-vitro* digestion technique.

2 Conrelation studies between *in vitro* and *in vivo* digestibility data on various fodder crops.

3 Applicability of the above techniques in final evaluation

(breeding) trials on cowpea, sorghum, guar, lucerne, berseem and oat.

4 Estimation of the nutritive value of different fodders and grasses, viz. guar, fodder turnip, sarson, *Heterpogon contortus* Dichanthium annulatum etc.

5 Utilization of Co and Cu from M. P. chari by growing kids and lactatingh goats.

6 Continuation of the studies on growth rate, sexual maturity and 1st lactation yield in Murrah x Nili cross heifers on forage based ration.

7 Continuation of the work on evaluation of berseem and guar hay-making in terms of nutrient losses, palatability and cost of production.

ation of the studies on the effect of feeding herbicide and allied chemically treated fodder on microbial population of the rumen.

EXTENSION AND ECONOMICS DIVISION

Salient features

Cultivation of M. P. chari for fodder was found most profitable with an input output ratio of 1:2.71 followed by Sunflower, M. P. chari (seed), teosinte and cowpea with the ratios of 1 : 2.50, 1 : 1.86, 1 : 1.30 and 1 : 1.14.

Analysis of data from an uniformity trial with cowpea (*Vigna siensis*) revealed that there was no appreciable decrease in the coefficient of variation beyond the plot size of 12m^2. The shape of plot had no consistent effect. Use of confounded designs appeared to result in gain in efficiency.

RESEARCH WORK DONE

AES-1 : STUDY ON YEAR-TO-YEAR COST OF CULTIVATION OF GENERAL CROPS (KHARIF) IN THE CENTRAL RESEARCH FARM

(Ram Prakash, H. H. Datta and S. P. Marwaha)

Cost of cultivation of the kharif crops, viz., M. P. chari (fodder) M. P. chari (seed), Cowpea (seed), Teosinte (seed) and Sunflower (seed) along with the relative contributions of the different inputs involved in their cultivation for the year 1971 had been worked out. Cost of production of M. P. chari (fodder) was Rs. 1.66/q during 1971, as against Rs. 1.99/q in the previous year. The fall of 16.6 per cent in the unit cost of output was caused by the large economies in use of manual labour and fertilizer which more than offset the loss by poor harvest on account of heavy and abnormal rains. Per quintal production cost of M. P. chari seed worked out to Rs. 134.52.

Cost of cowpea seed production was estimated at Rs. 175.98/q during this year, as compared to the corresponding figure of Rs. 103.14/q during the preceding year. This higher cost was attributed to use of high level of tractor power and considerable loss in yield due to

continuous and heavy rainfall during the crop growth. Cost of teosinte seed production was at Rs. 191.72/q during 1971, an increase of 14 per cent over the corresponding cost of Rs. 168.17/q during 1970, owing to use of higher level inputs like manual labour and tractor power without proportionate rise in yield.

Cultivation expenses per unit area of sunflower as seed crop worked out to Rs. 685.11/ha with the seed yield of 8.55 q/ha. Its cost per quintal was Rs. 80.13. The results of the input-output ratio for for these crops revealed that the cultivation of M. P. chari for fodder proved the most profitable having a ratio of 1 : 2.71, followed by sunflower, M. P. chari (seed), teosinte and cowpea with their respective ratios of 1 : 2.50, 1 : 1.86, 1 : 1.30 and 1 : 1.14 during the year 1971.

AES-4 : ALLIED STUDIES IN THE CENTRAL RESEARCH FARM

(a) Bullock maintenance cost

(Ram Prakash, H. H. Datta and A. K. Dabadghao)

Overall cost of bullock maintenance per pair per day and per hour, as well as, its allocation among the different constituents had been worked out from the half yearly data of July to December, 1971. Overall cost per day amounted to Rs, 6.79 during this period, as gainst Rs. 9.52 per day during the corresponding period of the previous year. This was mainly due to relative fall in total cost of fodders and feeds fed to the animals caused by subsititution of concentrates / roughages during this period.

(b) Cost of tractor operation

(Ram Prakash, H. H. Datta and Jai S ngh)

Overall. as well as, break-up cost of operation of two new Massey Ferguson tractors from the data collected for the year 1971-72 and also of two Russian Bylarus tractors and one old Massey Ferguson tractor from the data of July to December, 1971 was worked out. The analysis revealed that per hour cost of operation was Rs. 7.05 for the new Massey Ferguson (165), Rs. 5.66 for the new Massey Ferguson (135). Rs. 10.60 for Russian Bylarus No. 1. Rs. 16.60 For Russian

Bylarus No. 2 and Rs. 6.89 for the old Massey Ferguson. Per hour cost for the corresponding period of last year was Rs. 13.97 for Russian Bylarus No 1, Rs, 10 04 for Russian Bylarus No. 2 aad Rs. 9.88 for old Massey Forguson. These showed nearly 15 per cent reduction in the cost of operation of Russian Bylarus No. 1 and 30 per cent fall in that of old Massey Ferguson during 1971, as compared to 1970. This fall was mainly ascribed to better management resulting in substantial economy in repairs and replacements of these tractors. But, in case of Russian Bylarus No. 2 cost of operation rose relatively as high as 60 per cent during 1971 over that of the previous year on account of higher overhead cost per unit operation for its comparatively much less use.

(c) Cost of pump operation

(Ram Prakash, H. H. Datta and Jai Singh)

Overall as also break-up cost of operation of three pumps (each with 5 H. P. Diesel Engine) was worked out from the data collected for the year 1971-72. per hour cost of operation was Rs. 3.08 for pump No. 2 and Rs. 3.68 for pump No. 3 during this year, as against Rs. 4.22 and Rs. 4,47 respectively for them during last year. These two pumps registered a marked reduction in the unit cost of their operation over that of the previous year on account of their better utilization, as well as, care and maintenance. Per hour cost of operation of pump No. 1 was abnormally high (Rs. 13.95) during this year on account of its much lesser use (16 hours as compared to 144 hours in the previous year) causing a heavy drain on its unit overhead cost.

(d) Economics of fertilizer use

(H. H. Datta and Ram Prakash)

The data on green fodder yield and fertilizers under study were obtained from the published material relating to fertilizer experiment on multicut summer fodder sorghum (variety M. P. chari) conducted for two years 1969 and 1970 (Abichandani *et al* 1971). The experiment was conducted using all possible treatment combinations (81) comprising of four factors (i) Phosphorus at basal sowing (P), (ii) Nitrogen given after first cut (N_1), (iii) Nitrogen given after second cut (N_2).

(iv) Nitrogen given after third cut (N_3), each at three levels of 0, 30 and 60 kg/ha. 60 kg N/ha was applied basal at sowing to all the plots. The green fodder yield of the four cuttings (first three cuts at flowering and 3rd week of October for the fourth cut) was recorded, The nitrogen levels applied after first cut (N_1) were observed to follow the 'Law of Diminishing Returns' and as such, were taken into consideration in the present study; whereas, linear responses to nitrogen applications after second cut (N_2) and third cut (N_3) were observed and therefore, were left out of the study. The interaction effects of nitrogen and phosphorus having been statistically not significant were not considered for the purpose.

The study revealed that the maximum green fodder (total of four cuts) response was 1.98 q per kg of nitrogen (N) and 1.89 q per kg of Phosphorus (P) applied at the most profitable levels of 85.9 q/ha after first cut and 55.2 kg P_2O_5/ha basal respectively. Mean economic return on a rupee investment at the most profitable level was Rs. 3.19 in N and Rs. 2.62 in P_2O_5 taking the prices at Rs. 2.80 per kg of N, Rs. 3.25 per kg of P_2O_5 and Rs. 4.50 per quintal of green fodder. Effects of changes in prices of fertilizer and/or green fodder on the optimum amount of fertilizer use were also studied.

(e) Size and shape of plots and blocks for experimentation in the forage crops-Cowpea

(P. R. Sreenath and S. P. Marwaha)

Analysis of data from an uniformity trial with cowpea (*Vigna sinensis*) conducted at Central Research Farm, Jhansi revealed that the coefficient of veriation (C.V.) decreased with the increase in plot size. However there was no appreciable decrease in the C.V. beyond the plot size of 12 m^2 as in the case of M. P. Chari sorghum (*Sorghum bicolor* L. Moench). The equation $y=ax^{-b}$ gave a good fit to the underlying relationship between C. V. and plot size explaining more than 86 per cent of variation. The shape of plot had no consistent effect on C. V. With fixed experimental material, small plots were found more efficient Block efficiency decreased with an increase in block size. The relationship $Y=ax^b$ gave a good fit for relating the C. V. and block size. Use

of confounded designs were found to result in gain in efficiency over unconfounded design.

Research contemplated

1. Studies on the cost of cultivation of fodder crops at the Central Research Farm.
2. Comparative studies on the cost of agricultural operations using tractor and bullocks.
3. Survey on the economic aspects of grassland management and fodder production.
4. Study on the economics of livestock products,
5. Economic evaluation of the improved practices of forage production on the basis of input-output relationship.
6. Developi ng techniques of survey, sampling and experimentation in relation to grazing studies, range management and several other aspects of forage resources,
7. Designing field and laboratory experiments of the different Divisions.

AGRICULTURAL ENGINEERING SECTION

Salient features

The 'IGFRI Grass Seed Collector'. bullock and tractor-drawn 'Irrigation Channel-cum-Bund Former', 'IGFRI Smoke Screen Former', 'IGFRI Country Plough Mounted Seed Drill', are under release for general cultivation on a wide scale.

Field trials on Grass Seed Collector revealed that it can collect 2.5 to 15.0 kg seed per day from different grass species.

Use of Irrigation Chanel-cum-Bund Former' saves Rs. 18-24/ha in labour and 50-70% in time as compared to traditional methods of channel making.

For efficient operation in the field having channels and bunds suitable modifications in the imported flaed forage harvester model JF III have been made.

A functional prototype for mechanical separation of the chicory seed from berseem seed has been designed and developed. This could clean berseem seed to the extent of 90-95% purity.

The yeild of second cut in M. P. chari showed a descending order when harvested by tractor-drawn forage harvester, tractor-drawn mower and hand sickle irrespective of the degree of trampling. No adverse effect of trampling was found in case of oats.

RESEARCH WORK DONE

AE–1 : DESIGN, DEVELOPMENT AND EVALUATION OF FORAGE SEED COLLECTORS AND HARVESTERS (a) GRASS SEED COLLECTOR, (b) FORAGE HARVESTER.

(c) TRACTOR DRAWN IRRIGATION CHANNEL-CUM-BUND FORMER, (d) MECHANICAL CHICORY SEED SEPARATOR.

(Jai Singh and S. P. Marwaha)

(a) Grass Seed Collector.

The prototype developed during 1972 was subjected to field trials/tests. Provision was made for mechanisms for adjustments of the sweeping reel speed and sweeping pressure for efficient collection of ripened seeds from different grass species. The seed collection tests on grasses such as *Sehima. nervosum, Dichanthium annulatum, Hateropogon contortus, Cenchrus ciliaris* and *Cenchrus setigerus.* The machine was found to collect 2.5 to 15.0 kg seed per day (3 hours) depending upon the grass species, their stand and topography of the area.

(b) Tractor drawn "Irrigation Channel-cum-Bund Former"

This implement can make irrigation channels and/or bunds of desired sizes in a single operation without disturbing the level of the field and the sown seed. Its use reduces the cost of channel making by 70-75% as compared to that using the manual labour. The saving in time is 50-70% and in labour Rs. 18 to 24/ha. Several prototypes were developed and put to use in National Demonstrations.

(c) Chicory seed separator for cleaning berseem seed

An experimental model prototype was developed in the year 1971 to separate out chicory seed, which is a contaminant, in commercial quality of berseem seed, exploiting differences in their surface characteristics *viz.*, smoothness of berseem seed and roughness of chicory seed. The prototype which is manually operated was found to be highly efficient and ensured 90-95 per cent seed purity. The development of a mechanically operated prototype is in progress.

(d) Forage harvester

Evaluation studies of the flail forage harvester model JF III revealed that (i) soil from the top of the field channels and bunds was dug up by the machine while in operation and blown into the

accompanying trailer resulting in coiling up of the harvested fodder and (ii) the chopped material was not of acceptable lengths for silage making or immediate feeding purposes. To overcome these defects the main frame of the harvester was modified to cynchronise the upward and downward movements of the flail axle (cutting axle) with the movement of harvester on the ridges and furrows in the field. A shearing plate was provided for chopping the stalks into required lengths. With these modificatious the machine was tested under field conditions and the results were found satisfactory.

AE-3 : EFFECT OF MECHANICAL HARVESTERS ON REGENERATION AND PRODUCTION OF MULTICUT FODDER CROPS

(Jai Singh and M. N. Mishra)

The two trials on M. P. chari *(Sorghum bicolor)* in *khartf* season and on oat (*Avena savita* L.) in *rabi* season were repeated for the second year.

The M. P. chari crop for fodder was harvested twice (first cut at 55 days after sowing and second cut at 45 days after the first cut). It was observed that the fodder yield was of the order of 201 and 129 q/ha with the tractor-drawn forage harvester, 180 and 120 q/ha with tractor-drawn mower and 176 and 119 q/ha with manual lobour by sickle in the first and second cut respectively. The crop stands harvested with forage harvester regenerated quickly and showed greater tillering ability as compared to the mower and sickle harvesting.

AE-4 : DESIGN, DEVELOPMENT AND EVALUATION OF HAY BALER AND CRUSHER

(Jai Singh)

Blue print of a semi-automatic, stationary type hay baler was prepared. Fabrication of the functianal prototype was initiated. This machinine will be driven by bullocks.

MISCELLANEOUS WORKS

Petty works

Design, estimation and construction of 3 pump houses, 2 overhead tanks, one animal shed, a *sani* floor and 100 tree guards were completed. Construction of rabbit house, veterinary dispensary and lay out of underground R. C. C. pipe line were initiated. Three irrigation water pumping units (two of 5 h. p. and one of 15 h. p.) were energised. Energisation of another 20 h. p. pumping unit is in progress. Repairs of farm structures, irrigation channels, roads etc, was carried out as and when required.

Repair, maintenance and operation of farm machines

Maintenance, servicing and repairs of all the agricultural machines, implements (including irrigation) and maintenance and repairs of transport vehicles and laboratory equipments were carried out regularly. Field operations in the farm were carried out as and when required.

Farm development

The section of engineering was actively associated in land reclamation, levelling and grading, establishment of lawn and garden in farm and Institute campus and development of land around the Institute buildings.

Research contemplated

1. Design, development and evaluation of harvester, crusher rake and baler for hay making and handling.

2. Evaluation of the effect of engineering practices on moisture conservation and forage production in range grasses of *Sehima-Dichanthium* cover.

FARM SECTION

The various farm operations such as land preparation, sowing, formation of channels, erection of fences, weeding, harvesting atc., in

connection with the crops sown at the farm and natural grasslands were attended to in time. Repair and maintenance of channels, roads and fences were carried out.

Land reclamation and development work was vigorously pursued and about twenty hectares of additional land was suitably laid out for experimental purposes. Twelve hectares of grassland was cleared of bushes and rocks for undertaking cultivation and grassland experiments.

Different fodder and other crops, both for experimental and general purposes, were grown at the farm during the year under report. After meeting the requirements of the livestock maintained at the Istitute and after retaining plant and seed material for further experimentation, the surplus farm produce was disposed off by sale netting an income of about Rs. 1.67 lakhs during the year.

PUBLICATIONS

During the year 1972, the following research papers and articles of general interest pertaining to various aspects of forage production and its utilization were sent for publication to various scientific journals and/or presentation at various All India Seminars/Conferences.

1. Ahmad, S. T., Magoon, M. L. and Mehra, K. L. : Oat and Oat diseases at India Grassland and Fodder Research Institute, Jhansi, U. P., India. Oat Newsletter.

2. Ahmad, S. T., Magoon, M. L. and Mehra, K. L. : Screening of a world collection of cowpea for field resistance to leaf spot and virus. SABRAO News letter.

3. Amar Singh, Yadav, M. S., Magoon, M. L. and Mehra, K. L. : Dinanath grass—a cut-out for dairy farming. Indian Dairyman.

4. Dabadghao, P. M., Debroy, R and Marwaha, S. P. : The effect of interval and intensity of defoliation on the dry matter production of some important grass species of Western Rajasthan. Annals of Arid Zone. 12 : 1-8, 1973

5. Debroy, R and Pathak, P. S. : Forage Production in tropical dry deciduous community. Abstract of Annual Meeting National Academy of Sciences.

6. Dutta, T. R., Gupta, S. R. and Gupta, J. N. : Herbicides as regulants for stomatal closure in dryland farming. Current Science.

7. Gill, A. S., Maurya, R. K. Pandey, R. K., Mukhtar Singh, Mannikar, N. D. and Abichandani, C. T. : Effect of different levels of nitrogen and phosphorus on fodder yield and chemical composition of sorghum and cowpea. Indian Journal of Agril. Research.

8. Gopichandra, Mannikar, N. D., Karnani, J. T. and Abichandani, C. T. : Effect of rates and sources of nitrogen on the fodder yield and quality of oats (Kent). Fertilizer News.

9. Jai Singh : Design of a tractor drawn irrigational channel cum bund former. Journal of Agricultural Engineering.

10. Magoon, M. L. : March towards self-sufficiency in animal food. Indian Farming.

11. Magoon, M. L., Amar Singh and Mehra, K. L. : Forage legumes receive attention. Indian Farming.

12. Magoon, M. L., Amar Singh and Mehra, K. L. : Gene pool helps in improving fodder crops. Indian Farming.

13. Magoon, M. L. and Dabadghao, P. M. : Grassland Potential of India. Indian Farming.

14. Magoon, M. L. and Krishna, R. : Genetic improvement of tuber crops (other than potatoes) in India. Third International Symp. Sub-tropical and tropical Horticulture, Bangalore.

15. Magoon, M. L. and Krishnan, R. : Prospects and plans or the improvement of tuber plants (other than potatoes). Proc. All India Spmoosium on cytogenetics in the evolution and improvement of plants.

16. Magoon, M. L., Mehra, K. L., Amar Singh and Kohli, K. S. : Divergence and distribution of pigmentatation on plant parts in a world collection of cowpea *Vigna sinensis,* Genetica Iberica.

17. Magoon, M. L., Shri Ram, Singh, C. B. and Mehra, K. L. : Tolerance to leaf-hopper (*Empoasca kerri.* Pruthi). flea beetle (*Paqria signata* Matsch.) and Semi-looper (*Plusia nigrisigna* Wlk) infestation in a world collection of cowpea; inter riglonal comparisions. Ibid.

18. Mannikar, N. D., Gill, A. S., Maurya, R. K. and Abichandani, C. T. : Effect of stage of cuttingon fodder production,

seed yield and chemical composition of fodder sorghum M. P. chari. Indian J. Agric. Res.

19. Mehra, K. L., Bhag Mal and Kaiiyar, D. S. : Plant types in oat (*Avena sativa* L.) Indian Journal of Agril. Science.

20. Mehra, K. L. and Magoon, M. L. : Cytogenetical evolution and improvement of tropical forage grasses. Proc. All India Symposium on cytogenetics in the evolution and improvement of plants.

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SUMMARY

The year 1972 was very eventful for Indian Grassland and Fodder Research Institute, Jhansi because it witnessed the shifting of the Institute from the rented buildings in Jhansi city to its own new administrative and laboratory buildings which besides being spacious, also have modern and uptodate facilities including air conditioned rooms for housing sophisticated electronic equipments both imported and indigenous, useful for carrying out effectively integrated and multi-disciplined research on forage production and its utilization.

The research activities during the year were further intensified in proportion to the staff and facilities and some of the research findings of immediate practical value accomplished during the period are enumerated below.

The germplasm collection of forage plants were enriched with further additions raising the total number of genetic stocks to 4216 in grasses, 4462 in cultivated and pasture legumes and 159 in miscellaneous forage crops. Out of this gene pool, a large number of collections have been systematically screened and comprehensively evaluated for use as direct introductions and also as potentially desirable parents for a need based scientific breeding programme. Gene pool of cowpeas has been critically screened for desirable traits viz., earliness habit, branching degree etc. and the geographical sources of genes for the economic and other traits have been identified.

Promising selections in some range grasses have been identified which included : IGFRI-S-3108 in *Cenchrus ciliaris* yielding 1246 q/ha in seven cuts (over a period of three years) as against 985 q/ha of Pusa Giant Anjan (control); selections, IGFRI-595-1, IGFRI-495-3, IGFRI-3995-1 and IGFRI-495-5 in *Dichanthium annulatum* with cumulative green yields (in three cuts) ranging from 221 to 264 q/ha as compared to 146 q/ha of control, Marvel-8 and in *Pennisetum pedicellatum*, three high yielding selections namely IGFRI-S-3808-1 (1000 q/ha), IGFRI-

966-1 (960 q/ha) and IGFRI-31-1 (930 q/ha) proved superior as compared to the control T-1 (850 q/ha). In range legumes also, sev promising selections have been isolated in *Stylos* . . *gracilis* (IGFRI-S-4214-1 and IGFRI-S-96-1) with a yield potential of 432 and 416 q/ha of green fodder, respectively followed by IGFRI-S-4109-1 (410 q/ha) of *S. humilis* and IGFRI-S-230 (400 q/ha) of *S. sundaica* in three cuts in mono-culture as well as in mixture with Anjan grass. In butterfly pea *(Clitoria ternatea)* four promising selections IGFRI-S-23-1, 1GFRI-S-12-1, IGFRI-S-160-1 and IGFRI-S-7-1 exhibited superiority with a yield potential of 320, 305, 301 and 290 q/ha. respectively in three cuts.

Similarly, in the cultivated legumes, berseem selection IGFRI-S-99-1 proved superior in the local and multi-locational trials yielding 949.9 q/ha of green fodder as compared to 874.9 q/ha recorded in the control variety Pusa Giant berseem. Likewise in cowpeas, two selections IGFRI-S-450 and IGFRI-457 were found superior for multicut system under summer cropping/sowing with a yield potential of 490 and 545 q/ha of green fodder in two cuts as compared to 300-350 q/ha yielded by the control Russian giant while for *kharif* season, two varieties IGFRI-S-978 and IGFRI-985 excelled in the local and All-India yield trials with production potential of 449 and 481 q/ha of green fodder as compared to 325 q/ha produced by the control Sirsa-10. In lucerne, two promising selections IGFRI-S-244 and IGFRI-S-54 were found superior in the local and All-India trials yielding 859 and 746 q/ha of green fodder as compared to 666 q/ha recorded in the control variety Sirsa-9. In addition, new promising selections in the breeder's assembly lines that showed promise in the local trial were IGFRI-PC-2, IGFRI-PC-4, and IGFRI-PC-10.

The selections in respect of cultivated graminaceous fodders such as in Fodder Sorghums, IGFRI-S-452 (424.2 q/ha) and IGFRI-S-427 (422.5 q/ha) outyielded the control variety M. P. chari (370.7 q/ha) in green fodder production. Likewise selections tested at the Institute for their yield superiority under single cut and multicut (two cuts) management systems such as IGFRI-3014 (477.2 q/ha), IGFRI-3026 (424.5 q/ha), IGFRI-3021 (421.9 q/ha) proved outstanding in green fodder

yields over kent (383.1 q/ha) when cut at 50% bloom stage while selections IGFRI-S-3010 (459.3 q/ha), IGFRI-S-2636 (453.9 q/ha) and IGFRI-S- 3006 (448.6 q/ha) over Kent (400.5 q/ha) in cumulative green fodder yields of two cuts.

Fodder oat entries from the Institute namely, IGFRI-S-2688 a nd IGFRI-S-3021, on account of their consistancy in yield performance in coordinated trials conducted at several locations and superiority in crude protein yields have been recommended for pre-release multiplication by the third All-India Workshop on forage production and utilization. Other promising entries in these trials *inter alia* included IGFRI-S:3026, IGFRI-S-2660 and IGFRI-S-3014.

Field screening of germplasm collections against pests and diseases showed that most of the 195 oats collections including IGFRI-3020, IGFRI-3021 and IGFRI-3026 were resistant to leaf blight, leaf blotch and red leaf virus; 46 out of 410 cowpeas collections including IGFRI-457 were resistant to leaf spot and mosaic virus and IGFRI-Sun-3 showed resistance to leaf spot and powdery mildew out of the 10 promising lucerne cultivars studied.

The incidence of leaf hopper, flea beatle and semilooper in cowpea was controlled with granular formulation insecticides, Carbofuran, Dipterex, Rogor or spray formulations like Endosulfan. In the absence of any chemical protection, the yield losses in susceptible varieties of cowpeas were found to be as high as 34%.

Alongside the evolution of high yielding varieties and plant protection measures to combat diseases and pests, a package of agronomic practices have also been standardised for maximised fodder production per unit area, per unit time. In the studies aimed at obtaining green fodder production round the year, an overlapping system including berseem+Japan sarson, Napier-Bajra hybrid and cowpea fodder crops, has been found useful. In this system, mixed sowing of berseem (25 kg/ha)+Japan *sarson* (1 kg/ha) is done in October. A basal dressing of 20 kg N+80 kg P_2O_5/ha is given at sowing. In the first year, Napier-Bajra hybrid rooted slips are interplanted at a distance of 1 m (row to row) x 30 cm (plant to plant) in standing berseem, after the third cut

of berseem (i. e. February/March). A catch crop of cowpeas during late April/early June is sown in rows 25 cm apart in the inter-row spaces of Napier-Bajra hybrid after the berseem crop is over. 50 Kg N/ha is given as top dressing after each cut of hybrid napier. While the hybrid napier once planted is continued for three years, the berseem+sarson and cowpeas are sown every year as mentioned above. This system takes advantage of dormant period of hybrid napier for growing berseem crop. Thus a total yield of 2863 and 2599 q/ha of green fodder averaging 7.8 and 7.1 q/ha/day in the first and second years of the experiment, respectively was obtained by adopting this system.

In the normal practice of wheat-jowar rotation followed in the Bundelkhand tract, a gap period of fallow between April to June exists. To fill in this gap period usefully, a successful attempt was made with the fodder mixtures viz., M. P. chari+cowpeas, bajra+cowpeas or Maize+cowpeas. These mixtures have given an additional green fodder yield of about 300 q/ha without affecting the yields of the wheat and jowar crops of the rotation.

In berseem and oats, it was found that by rational use of irrigation, economy in water use could be ensured without affecting seed production in these crops. Thus, in berseem, application of two irrigations at 15 and 30 days after taking the third cutting resulted in seed yield of 4.46 q/ha with four irrigations given at 15 days interval starting from the third cut. In oats, two irrigations at late tillering and flowering stages are found sufficient for normal seed production.

The efficiency of spray grade and fertilizer grade urea as a source of N for foliar spray was evaluated in field trials with M. P. chari, teosinte and oats. Foliar spray of 15 kg N/ha as spray grade urea (SGU) and fertilizer grade urea (FGU) at boot stage of M. P. chari in addition to 60 kg N/ha (basal) resulted in increased green fodder yields by 59.1 q/ha (19.5 q/ha D. M.) and 42.2 (15.2 q/ha D. M.), respectively over the green fodder yield of 236 q/ha (74.7 q/ha D. M.) for basal manuring alone. In teosinte, the highest green fodder yield of 391 q/ha (131.7 q/ha D. M.) was obtained with SGU applied at 75 days growth, giving a significant increase of 128 q/ha (45.4 q/ha D. M.) in the green fodder

yield over no spray; and 62 and 73 q/ha (25.3 and 31.2 q/ha D. M.) over FGU sprayed at 60 and 90 days growth stages, respectively. The results in oats indicated that a maximum of 485 q/ha of green fodder was obtained when SGU was sprayed 60 days after sowing as compared to 462 q/ha obtained by foliar spray of FGU at same stage of growth.

An uniformity trial conducted with cowpea revealed that there was no appreciable decrease in the coefficient of variation beyond the plot size of 12 m^2. The shapes of plot had no consistent effect. Use of confounded designs appeared to result in gain in efficiency.

Survey, collection and mapping of weeds were undertaken in Bundelkhan dand several places in the eastern zone representing different agro-climatic regions for ascertaining the incidence of *Kharif* weeds. About 240 weed specimens were collected for the weed herbarium.

Foliar spray of diuron or atrazine at $M \times 14^{-6}$ appeared to act as an antitranspirant resulting in increased grain yield and improved harvest index. Ammonium sulphamate has indicated potentials for brush control in grasslands. Benz-meth-carbamate and meto-bromuron appeared to be well tolerated by six *rabi* crops. ACP 68–64 gave good promise for enhancement of berseem seed yields through bio-regulation. Differential tolerance for atrazine was indicated in fodder sorghum varieties, M. P. chari, J. S. 20 and Swarna. Alachlor was promising in *okra*–wheet rotations.

Sensitive methods for determination of diuron and cotoran are being developed for detection of residues in fodder crop produce. Alachlor or Nitralin used for weed control in soyabean did not alter the quality constituents. Atrazine treated fodder sorghum did not cause any health hazard in rabbits.

Weed control as an input in various fodder crop rotations are being investigated and some useful measures for control of weeds in fodder sorghum, sarson etc., have been standardised.

While efforts in maximising the fodder production through the cultivation of superior cultivers and adoption of package of agronomic

practices including plant protection measures were aimed at providing lush nutritious fodder for the highly productive milch animals, studies on grasslands and cultivated pastures were directed in raising their productivity and quality for meeting the requirements of the dry cattle, sheep and goats.

Primary production studies in *Chrysopogon* grasslands revealed the highest production of litter (294 g/m^2 in the month of february. However, in the case of aboveground biomass the peak Production of 216 g/m^2 was obtained in September. The underground biomass in the same period was 497 g/m^2. The corresponding figures in *Iseilema* grasslands were 182 and 290 g/m^{2}for above and below-ground biomass, respectively. The litter production in *Iseilema* was negligible except in March when dry matter yeild was 38.7 g/m^2.

Studies to define the production potential of *Heteropogon contortus* (Lampa *ghas*) grasslands through fertilizer use showed that their response to the application of nitrogenous fertilizer was linear and the rate of 90 kg N/ha (450 kg of Ammonium sulphate/ha) resulted in the highest dry matter yield of 75 q/ha as compared to the yield of 45 q/ha with 30 kg N/ha.

Fertilizer application to *Sehima nervosum*-grasslands also showed linear response to nitrogen levels varying from 30 to 120 kg N/ha. The dry herbage yield increased from 36.0 q/ha with 30 kg N/ha to 78.3 q/ha with the application of 120 kg N/ha. Phosphorus application did not show any significant response.

Studies on fertilizer use in cultivated pastures of *Cenchrus ciliaris* showed a linear response to application of nitrogen upto 90 kg N/ha which resulted in the highest dry forage yield of 64.7 q/ha as compared to 15 q/ha in control (no nitrogen).

Among the suitable techniques investigated for establishment of pasture legumes *Stylosanthes humilis* and *S. gracilis*, in *Sehima–Heteropogon* grasslands, the premonsoon dibbling resulted in the highest establishment (21,000 plants/ha) in the former, while line sowing in monsoon and application of 20 kg P_2O_5/ha gave best establishment in the latter (13,300 plants/ha).

Relative grazing values of important grasses using Mandya sheep showed that in *Cenchrus* pastures, the sheep recorded an average live-weight gain of 1.7 kg/sheep during August to November (85 days). However, in *Sehima nervosum* grasslands the sheep could only maintain their body weight for a relatively shorter period (i. e. August to September).

Studies on the effect of three sowing densities (11466, 18333 and 31666 plants/ha) and three intervals and intensities of cutting (10, 20 and 30 cm height) in *Leucaena leucocephala* showed that maximum dry matter yield (132 q/ha) was obtained in plant density of 31666 plants/ha cut at 30 cm height at an interval of 60 days followed by 104 q/ha for the same density cut at 30 cm height at intervals of 40 days. Cutting after 120 days resulted in early flowering and fruiting due to which the leaf dry weight was reduced.

Burning, as a practice, annually, biennially or triennially followed by grazing increased the percentage composition of *Heteropogon contortus* and decreased that of *Sehima nervosnm*. In the first two years, grazing generally promoted *Sehima nervosum* but did not favour *Heterpogon contortus*. However, in the third and fourth years the percentage composition of *Sehima* showed decreasing trend while that of *Heteropogon* showed a rising trend.

The present socio-economic demands of our country dictate the necessity for adopting integrated land use pattern particularly in plantation crops for ensuring maximum benefit in the intervening gestation period of the plantation crop. Thus *Cenchrus ciliaris* grass was successfully grown in the interspaces of fodder trees *Leucaena leucocephala* (planted at espacement of 4m × 4m) and *Acacia tortilis* (6m × 4m) and besides taking the fodder/fuel from the trees, an yield of about 43 q/ha of dry grass was also obtained.

Basic studies on germination and storage of seeds of grasses and fodder trees were also conducted. It was found that seeds of *Sehima nervosum* stored for 16 months showed highest germination at alternating temperature of 32° 18°C and at a moisture stress of 5–7 atmospheres. In the case of seeds of *Cenchurs ciliaris, C. setigerus, Dichanthium*

annulatum and *Chrysopogon fulvus* stored for 2 years, highest germination was recorded at 32°C. Seeds of fodder trees *Leucaena leucocephala* and *Acacia tortilis* showed optimum germination when treated with concentrated sulphuric acid for 10 and 50 minutes respectively.

Studies on nutritional evaluation of promising materials of various forage crops were furher strengthened. For instance, twelve varieties of lucerne were evaluated to find out their "gross" nutrients yield and three varieties showed superiority on account of their high crude protein yield which varied from 2526 to 2732 kg/ha.

Fifteen, single-cut, varieties of oats were chemically evaluated. Three varieties (IGFRI-2688, fulgham and IGFRI-3008) were found promising due to their high crude protein yield at 50% bloom stage. The respective yields were 736, 733 and 711 kg/ha.

Effect of various fertilizer treatments on the "gross" nutrients content and yield in oats and lucerne showed that an application of 120 kg N and 60 kg P_2O_5 in oats and 120 kg P_2O_5 and 40 kg K_2O in lucerne gave the maximum yields of crude protein amounting to 860 kg and 2603 kg/ha. respectively.

Studies on the effect of soil-moisture strees on the HCN content of summer-grown M. P. chari revealed that in the absence of soil-moisture stress during the first 32 days of crop growth, the 42 days old crop could be safely fed to animals, while moisture stress during this period rendered the crop unsafe (due to high HCN content) for animal consuption untill the 52nd day.

In vitro and digestibility-*cum*-metabolism trials were conducted to study the nutritive changes in fodder oats, variety Kent, as influenced by stage of maturity and conservation practices. The results showed that the digestibility coefficients of all the constituents of fodder oats decreased with advancing maturity. Both the *in vivo* and *in vitro* digestibilities of dry matter were lowered by silage making probably due to high ash content. The DCP content was higher in hay (9.0%) than green (8.0%), while it was reduced in silage (7.1%). The maximum yield of DCP was obtained at milk stage (5.17 kg/day or 765.4 kg/ha)

while the maximum yield of TDN was obtained at dough stage (53.6 kg/day or 9105.0 kg/ha). From the above observations, it is concluded that fodder oat variety kent should be harvested at milk/dough stage of growth for obtaining the maximum DCP and TDN yields.

Nutritive values of cowpeas and M. P. chari at 50% and full bloom stages of growth, respectively were determined in Hariana bullocks. The digestibility coefficient of dry matter, DCP and TDN values of M. P. chari were found to be 57.4%, 2.3%, and 55.3% and those of cowpea were 65,8%, 10.4% and 64.7%, respectively,

A feeding trial on individual *vs* group feeding was conducted in Barbari bucks. Berseem hay was fed for six weeks and the intake of berseem hay was found to be more in group-fed animals (2.5 kg/100 kg body weight) than that in individually-fed animals (2.0 kg/100 kg body weight).

Comparative efficiency of hay making in berseem by three different methods indicated that "IGFRI fence method" was economical (Rs. 1.20/q) over the chaffed method (Rs. 3.60/q). The quality of hay was also markedly superior and it maintained a bright green colour.

As a result of concerted efforts made in the design and development of farm equipments, keeping in view, the needs of marginal farmers in particular. several implements such as 'IGFRI Grass Seed Collector, bullock and tractor-drawn 'IGFRI Irrigation Channel-cum-Bund Former', 'IGFRI Smoke Screen Former', 'IGFRI Country plough Mounted Seed Drill,' 'IGFRI Herbicide Injector', which have been developed, were widely tested under the National Demonstration Scheme.

Field trials on Grass Seed Collector revealed that it can collect about 2.5 to 15.0 kg ripened seed per working day against 200 to 500 gm by manual method from different grass species. Use of Irrigation Channel-cum-Bund Former reverals 11-24/ha in labour cost and 50-70% in time as compared to traditional methods of channel making. The Smoke Screen Former helps in protecting plants vulnerable to frost

damage by creating a thick layer of smoke over the crop. One equipment can approximately command an area of 3 hectares. The country plough Mounted Seed Drill, specially meant for seeding lucerne by the side of ridges can also satisfactorily sow the seeds of other forage and cereal crops. It can cover an area of 1.25 ha/day. The herbicide injector can directly apply the desired quantity of herbicide/weedicide into plants stem without cutting/smearing the stem. A functional prototype of mechanical separation of the 'chicory' weed seed from berseem seed has been designed and developed. It can clean berseem seed to the extant of 90-95% purity. Suitable modifications in the imported flail forage harvester model JF III have also been made for efficient operation in the fields having channels and bunds.

The yield in second cut of M. P. chari (45 days after the first cut) showed a descending order of 129, 120 and 119 q/ha when harvested by tractor-drawn mower and hand sickle, irrespective of the degree of trampling. No adverse effect of trampling was found in case of oats.

Studies are underway for working out the cost of cultivation of various *kharif* and *rabi* fodder crops. The results so far obtained have in dicated that the cultivation of M. P. chari for fodder gives a return of Rs.2.71per every rupee of investment. The cultivation of Sunflower and M. P. chari(for seed)during *kharif* season were also found remunerative with input-output ratios of 1.00 : 2.50 and 1.00 : 1.86, respectively.

In addition to carrying out multidisciplined research aimed at maximised forage production for highest animal production, the Institute has made concerted efforts in maintaining liaison between the cultivators, extension personnel and research workers and advisory services were rendered to interested agriculturists. Informations on matters of technical and general nature on different aspects of cultivation of grasses and fodders were given to various private and government agencies by visiting their areas, if necessary.

That is not all During the year 1972, the Institute conducted six National Demonstration trials in Uttar Pradesh with the active

support of the State Government and State Coordinated Committee on Grassland and Fodder Development in U. P. Out of the six demonstrations, four were of two crop rotations and the remaining two trials were of one crop rotation. The crop rotations were so selected that one or both the crops were of fodder as approved in the earlier workshops. The results have shown that the growing of fodder crops in a single year either in two crop rotation or in one crop rotation is more economical and the targets fixed (60 tons of green fodder/ha/year) were well achieved.