Agricultural Education and Research in the Jurisdiction of RVSKVV, Gwalior (M. P.)

(Pre - Independence Period : 1916-1947)

Volume - I

Visit of Indore Composting Method at IPI, Indore by Father of the Nation Mahatma Gandhi Ji on April 23, 1935

Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya
Gwalior - 474002 (M.P.)

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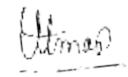
PREFACE

Agriculture is the source of perpetual creation on which civilization depends. It has a dominant role in the Indian economy. Majority of The Indian population directly or indirectly depends on agriculture. It provides employment to about seventy per cent of the working population in India and raw material for most of our industries. It also accounts for sizable share of the country's foreign-exchange earnings. Apart from these material considerations, it is a way of life, unique and irreplaceable in human values. A thorough investigation of the history of agriculture is, therefore, a most important though difficult task to execute. While in some other parts of the world and the country this has been attempted. In Madhya Pradesh, however, this subject has not received the much recognition as it deserved. It is therefore gratifying that this has at last been done by the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior.

I deeply appreciate the efforts of such a team of dedicated scientists of whom none is more proud than myself and the Directorate that coordinates and builds up their efforts, i.e., the Directorate of Extension Services. The book will continuously need review of our progressive efforts and I am sure, the chain will not be broken to provide an updated information for interested parties. The book will be of interest to a wide variety of persons including all those interested in agriculture. It will, of course, be of special interest to those who wish to understand agriculture under the jurisdiction of RVSKVV, Gwalior. The book will be of valuable reference to scholars and students as well as to the common man.

I wish the team a great success for their endeavours to come up true to the expectations of the University to which they have the privilege to belong. All constructive criticisms and suggestions pertaining to contents and format of this valued publication by the readers are welcome in order to improve the future edition.



(V. S. Tomar)
Vice - Chancellor

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We feel grateful to acknowledge the whole heartedly made contributions from Dr. G. P. Verma, Former Director Research Services, JNKVV, Jabalpur, Dr. O. P. Verma, Former Dean, College of Agriculture, Gwalior and Dr. P. R. Rajput, Retd. Prof. (Agronomy), G.B.P.U.A.T., Pantnagar for providing us a great information base for the compilation.

We are thankful to Dr. A. S. Tiwari, Ex. Vice Chancellor, JNKVV, Jabalpur, for his valuable suggestions and help in preparation of this valued publication .

We put on record our gratitudes for the support rendered by the Dean Faculty Agriculture, Directors and Deans, ADRs, Librarian and Programme Coordinators of the RVSKVV, Gwalior, whose contributions made this publication meaningful.

We also put on record our sincere thanks to technical assistance provided by Dr. S. S. Bhadauria, Dr. Neeraj Hada, Dr. S. S. Kushwah and Dr. Shobhana Gupta who had made no stone unturned in providing their inputs for shaping this publication.

We also recognize the contribution of Dr. S. S. Kushwah, I/c Communication Centre of the Directorate of Extension, RVSKVV, Gwalior for his valuable help in printing out this important publication.

EDITORS

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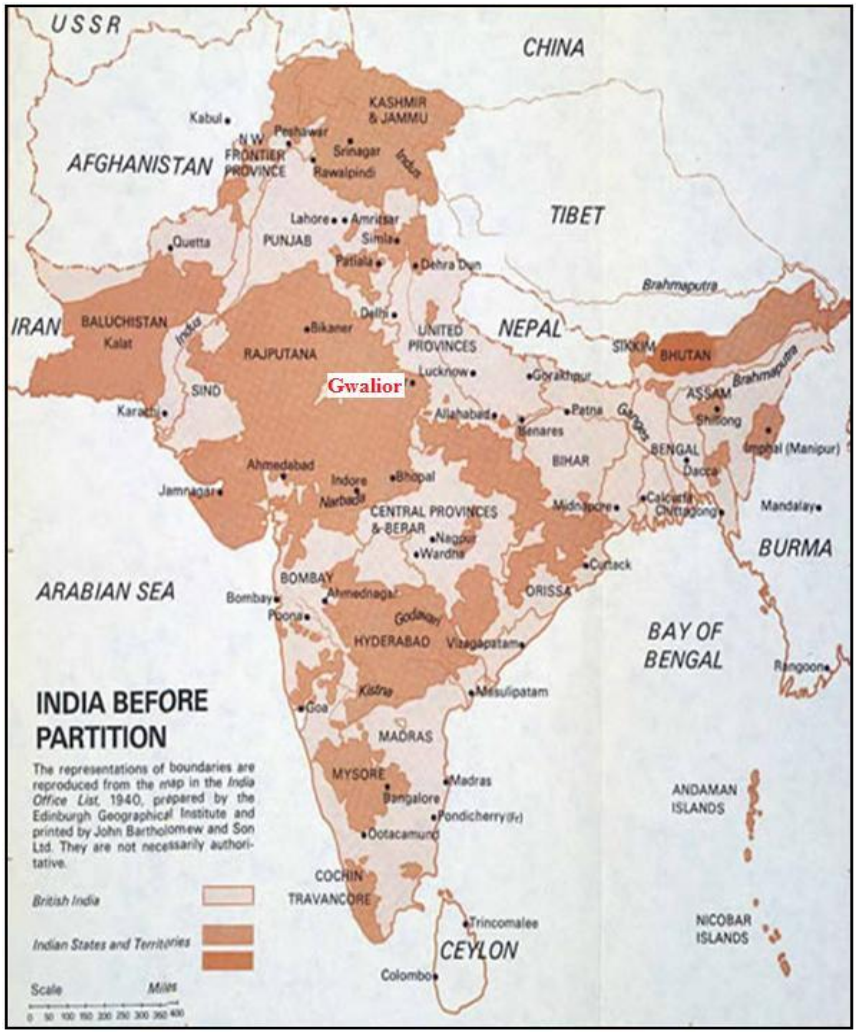
INTRODUCTION

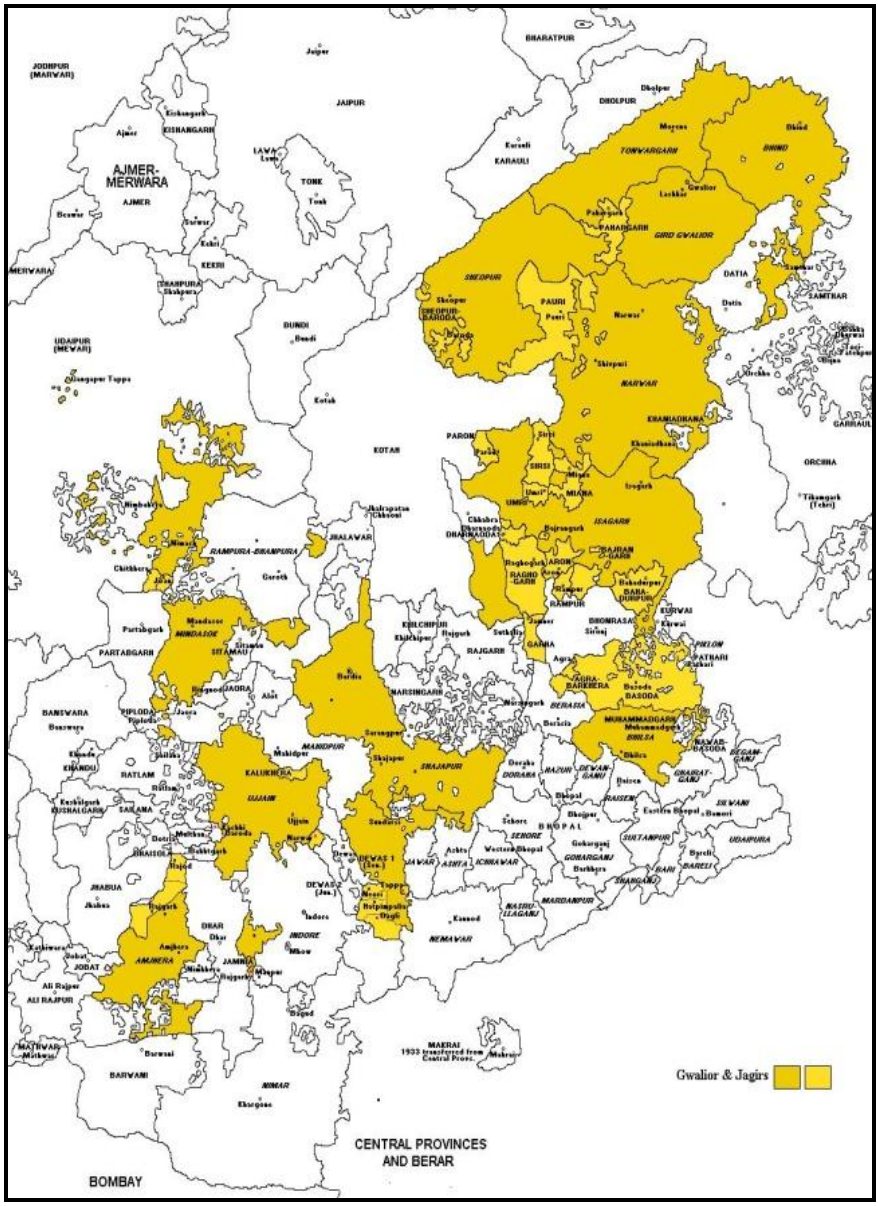
The Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior is responsible for agricultural education, research and extension in 25 revenue districts (Alirajpur, Ashok Nagar, Badwani, Bhind, Bhopal, Burhanpur, Datia, Dewas, Dhar, Guna, Gwalior, Indore, Jhabua, Khandwa, Mandsaur, Morena, Neemuch, Rajgarh, Ratlam, Sehore, Shajapur, Sheopur, Shivpuri and Ujjain) of the Madhya Pradesh state. During pre-independence period, some of these districts were under the jurisdiction of Gwalior state.

Gwalior state was an Indian kingdom and princely state ruled by the Scindia dynasty of the Marathas. The state took its name from the old town of Gwalior, which, although never the actual capital, was an important place because of its strategic location and the strength of its fort. The state was founded in the early 18th century by Ranoji Sindhia as part of the Maratha Confederacy. Under Mahadji Sindhia (1761-1794) Gwalior state became a leading power in northern India and dominated the affairs of the confederacy. The Anglo-Maratha Wars brought Gwalior state under British suzerainty, so that it became a princely state of the British Indian Empire. Gwalior was the largest state in the Central India Agency, under the political supervision of a Resident at Gwalior. In 1936, the Gwalior residency was separated from the Central India Agency and made answerable directly to the Governor-General of India. After Indian Independence in 1947, the Sindhia rulers acceded to the new Union of India and Gwalior state was absorted into the new Indian state of Madhya Bharat.

The state had a total area of 64,856 sq. km and was composed of several detached portions, but was roughly divided into two, the Gwalior or Northern section and the Malwa section. The northern section consisted of a compact block of territory with area of 44,082 sq. km, lying between 22^{o}10′ and 26^{o}52′ N. and 74^{o}38′ E. It was bounded on the north, northeast and northwest by the Chambal River, which separated it from the native states of Dholpur, Karauli and Jaipur in the Rajputana Agency; on the east by the british districts of Jalaun and Jhansi in the United Provinces and by Saugor District in the Central Provinces; on the south by the states of Bhopal, Khilchipur, Rajgarh and by the Sironj pargana of Tonk State; and on the west by the states of Jhalawar, Tonk and Kotah in the Rajputana Agency. The Malwa section, which included the city of Ujjain, had an area of 20,774 sq. km. It was made up of several detached districts, between which portions of other states were interposed and which were themselves intermingled in bewildering intricacy.

For administrative purposes the state was divided into two prants or divisions; Northern Gwalior and Malwa. Northern Gwalior comprised of seven zilas or district: Gwalior Gird, Bhind, Sheopur, Tonwarghar, Isagarh, Bhilsa and Narwar. The Malwa Prant comprised of four zilas.Ujjain, Mandsaur, Shajapur and Amjhera. The zilas were subdivided into parganas, the villages in a pargana being grouped into circles, each under a patwari.





Gwalior state in 1947

I. ESTABLISHMENT OF DEPARTMENT OF AGRICULTURE

The Department of Agriculture of the Gwalior state came into existence on July 1, 1916 with Dr. Sam Higginbottom as Director of Agriculture and Mr. Don W. Griffin as Agricultural Engineer.

Dr. Sam Higginbottom
Founder Director of Agriculture (1916-17 to 1918-19)
Gwalior state

The aims and duties of the newly created Department were:

1. to make the cultivation of the staple crops of the state more economical and in particular for the benefitof the farming population,
2. to see that the Demonstration farms and Demonstration villages in each District and manage them in such manner as to, be an encouragement to the cultivators of the district and set them the example of farming for profit,
3. to use these farms and villages as seed farms and study farms,
4. to provide good seed of all the staple crops,
5. to introduce new crops likely to be profitable,
6. to introduce machinery likely to be economical and useful to the ordinary cultivator as well as the large Zamindars,
7. to point out to the cultivators, the benefits of co-operation in Agriculture,
8. to help the cattle industry by having good bulls and developing dairies,
9. to improve the sheep of the state and increasing their number,
10. to demonstrate improved methods of farming,
11. to hold local Agriculture Exhibitions in different parts of the State,
12. by means of laboratories and experts to carry on Agriculture experiments likely to benefit the state. To control plant and animal diseases,

13. by all means to seek the improvement of the farming community in material things, in broadening the vision of the people, in giving them hope,
14. to show by demonstration the importance of Agriculture as the basis of the wealth and welfare of the State,
15. to popularise the study of Agriculture among the educated classes and get them to establish demonstration farms for the benefit of their tenants,
16. to train cultivators and students to use better methods and implements, and
17. to assist chakdars and others with agriculture advice and help.

The aforesaid objectives were realised through the following agencies:

1.Central Experimental Farms.

2.Agricultural Research Laboratories.

3.Demonstrations and Propaganda Section

4.Civil Veterinary Section.

5.Dairy and Bull-Breeding Farm.

6.Agricultural Engineering Section (including boring).

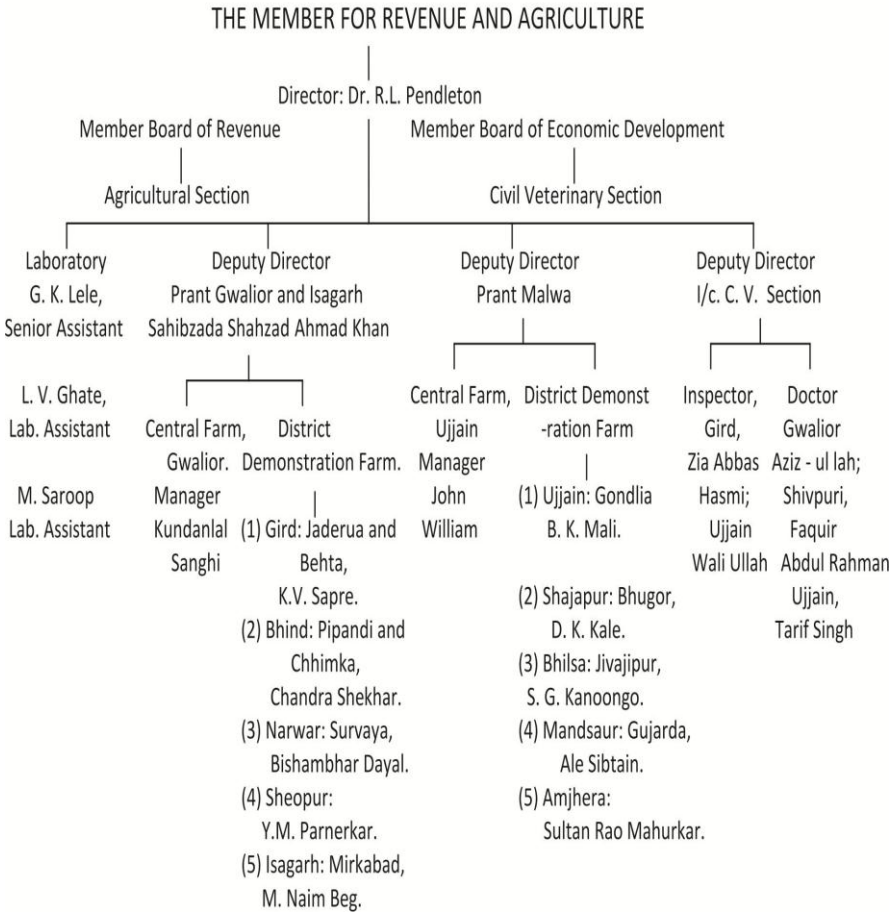
The first period of three years was spent in organizing the Department of Agriculture, establishing Central Experimental Farms, equipping the Agricultural Research Laboratories and in training necessary staff at the Ewing Christian College, Allahabad.

Dr. R.L. Pendleton came as full time Director towards the middle of the year 1919. He tried his best to carry out as fully as possible the Darbar orders that were passed from time to time. The work, however, could be systematised till the Agricultural Manual was framed and brought into force in the year 1923. The schematic representation of the organization of the Department is given in the chart as mentioned below.

CONVERSION TABLE

*1 Maund = 37.324 kg
*1 Seer = 0.9331 kg
*1 Bigha = 2000 sq. m.

Consitution of the Agricultural Department During the year 1922 - 23



II. AGENCIES CREATED

The Department of Agriculture created several agencies (section/ laboratories/ farms) to realize the aims and duties given to it. Some facilities were created in the beginning and some were added later on as given below.

(A) Central Experimental Farms

In the beginning, two Central Experimental Farms, one at Lashkar for the Gwalior Division and the other at Ujjain for Malwa Division, were established. As the soil and climate conditions at both of these places were extremely different, crop experiments had to be carried on different lines. Mention is made below of some of the most important activities done at these farms

1. Introduction and acclimatisation of improved varieties of crops from other parts of India.
2. Selection and identification of most important varieties of staple crops grown in different parts of the State.
3. Introduction of pure varieties of crops in different districts.
4. Studying the effects of well preserved farmyard manure, cake manure, and green manure on different crops.
5. Studying the effects of different methods of cultivation on crop production.
6. Studying the efficiency of different types of country as well as improved implements like ploughs, drills, etc.
7. Studying the methods of improving soil condition by tillage, manure, etc.
8. Studying the methods of conserving soil moisture.
9. Crops studied on these farms included jowar, cotton, wheat, gram, sugarcane and groundnuts. Attention was also paid to arhar, bajra, tilli, tobacco and linseed. Work on cotton was mostly concentrated at the Central Farm, Ujjain.

To acquaint cultivators of villages, situated near about the Central Farms, people were invited once every year, when the crops were standing on what was called the “Farmer’s Day”. Many people used to come and return with learning something new on this occasion (Pandya, 1931).

(i) Central Experimental Farm, Gwalior

This farm was established in 1917, situated just opposite to the Mela Ground on the left of Lashkar Etawah Road. The farm occupies in all an area of 284 bighas*, out of which some 30 bighas* come under Staff Bunglows, Laboratory, Workshop, Implement Stores, Farm Buildings, Roads, etc.(ARDA, 1918-19).

The Meteorological observatory for the record of weather data was established in the year 1938-39. Since then weather data are being recorded daily at 8 A.M. and 5 P.M. (ARDA, 1938-39).

(ii) Central Experimental Farm, Ujjain

In May 1920, the Ujjain Experimental Farm was placed under the control of the Agricultural Department. This Experimental Farm was started prior to the establishment of the Agriculture Department. The so called "Experimental Farm" was composed of the Palace gardens and about 200 acres of garden and agriculture land around the new Palace. It was the original idea of the Darbar to give the outlying area of the Palace grounds to the Agricultural Department (ARDA, 1919-20).

(B) Agricultural Research Laboratories

The Agricultural Laboratory was established with two Divisions of Chemistry and Botany during the year 1917 under the guidance of Dr. Sam Higginbottam (the distinguished founder of the Allahabad Agriculture Institute) as Director of Agriculture with eminent assistants like Dr. R. L. Pendelton and Dr. L.A. Kenoyer as Botanist.

In 1930, as a measure of retrenchment anent to general depression in the country, the Agriculture and the Scindia Chemical Laboratory (a separate organisation with an industrial bias but working under the Department of Agriculture) were amalgamated in to one known then as Chemical and Botanical Laboratory, with scope of work of the Chemical Section much widened so as to include all sort of analytical work on samples received from the various departments as also medico-legal samples from the Government Medical Department of Gwalior. After passing through the vicissitudes described above, under the reorganisation done more than a decade ago, the scope of work of the research organisation was still further widened with addition of two more sections viz. (I) Mycology and (II) Entomology in 1941 and the

organisation with four different divisions styled as Agricultural Research Laboratories.

(C) Scindia Chemical Laboratory

Primarily started for research work in Forest Products and run under the Trade Department had in course of time many of its activities curtailed and subsequently in year 1925 was transferred to the Agriculture Department, according to the new scheme both the aforesaid laboratories have been amalgamated.

(D) Demonstration and Propaganda Section

With the objective of educating cultivators, both morally and materially, Updeshaks, maintained from Zamindars Hitkari Fund, were put under the Agriculture Department in the year 1924 to work on lines laid out in Memorandum No. 22. This arrangement, however, could not be continued for a long time.

Considering the importance of agriculture and allied sector, four posts of Naib Tehsildars for seed distribution were created in 1926. This number was quite inadequate as the extent of state was vast. When the new re-organizing scheme was submitted to the Darbar. It was emphasized that if any useful purpose of the Department of Agriculture was to be served, that can only be achieved by having a body of men trained in the science and practice of agriculture with at least one man for each Tehsil to begin with. In the new scheme which was sanctioned in the year 1930 five posts of Inspectors and thirty-four posts of Naib Tehsildars (Demonstration and Propaganda) were sanctioned. By this arrangement nearly one man was placed in each Tehsil. It was expected that as a result of their constant and immediate touch with the agriculturists, real purpose of the Department will be fulfilledto a great extent.

Duties assigned to Demonstration and Propaganda staff were:

1. to study local conditions and local requirements of the people,
2. to supply seed of high yielding improved strains of staple crops and demonstrate practical methods of raising them on cultivators own fields,
3. to advise and encourage cultivators to preserve their own seed by selecting best plants and ear heads from the standing crops and to grow better crops by using their own seed as well as the one raised on the Central Farms and

4. to organize (a) Demonstration Plots and (b) Seed Growing Centres in co-operation with the cultivators:-

   (a) Demonstration Plots: In this cultivators were asked to try some of high yielding crops (formerly tested on the Experimental Farms) on their own lands with their own hands and allowed to satisfy themselves with their benefits. The effect of such field demonstration plots should no doubt be immediate and convincing to the agriculturists.

   (b) Seed Centres: In the beginning a limited good selected seed was produced on the Experimental Farms and then distributed to selected cultivators, commonly styled as "Certified seed growers." Seed raised by growers under the care and guidance of the Department and again distributed to a number of cultivators in different parts of the State. In this way the course of production and distribution was channelised. In order to ensure the purity of types such plots were required to be often watched by the Naib Tehsildars and corrected by removing alien plants, wherever necessary. Thus in multiplying the stock of good seed, the Department had nothing to spend, except that they encouraged seed growers by giving premium for the best production.

5. to advise and show cultivators how different kinds of manures (such as cattle manure, green manure of sun hemp, oil cakes, bones etc.) could be used with profit by applying them to various crops in a systematic manner,
6. to demonstrate common methods of combating crop pests and crop diseases,
7. to popularise, introduce and train cultivators the use of improved bullock driven and hand power implements,
8. to organise "Agriculture Associations" to discuss and push on improved methods of agriculture, suitable for each Tehsil,
9. to tour and lecture on the topics of Agricultural improvements,
10. to advise interested zamindars and cultivators to get pure bred bulls through District Boards or direct (1) from, Manager, Dairy and Bull Breeding Farm, Maharajpur Gwalior, or (2) from Deputy Administrative Officer, Agricultural Section, Malwa Division, Ujjain, and improve local stock of animals by covering all cows with such bulls only; castrating at the same young stock

before they were one to two years of age, thus putting a stop to indiscriminate breeding and

11. to do propaganda work on behalf of Agricultural Engineering section in such districts, where power ploughing and boring works were in progress. Orders secured for ploughing or boring being transferred to the Agricultural Engineer for final disposal.

In order to concentrate the work of demonstration and propaganda and to arrive at some definite results arrangements were made to centralize such activities only in selected villages in each district. To begin with about 20 to 25 representative villages were selected in each Tehsil. Many of the items outlined in the programme stated above were taken up in these villages for at least a period of three years.

Besides the work of district demonstration and propaganda one motor lorry equipped with Cinema apparatus and a collection of agriculture products was also provided to form part of a moving exhibition. It was expected to draw large number of people for the Cinema Shows and thus induce farmers to take interest in what the Department was doing for them. About a dozen films of agricultural topics were obtained from the Department of Agriculture, U.S. America, and some more were added to stock by preparing them locally.

(E) Civil Veterinary Section

Thiswas started in the year 1909, and continued to work under the Revenue Department till it was brought under the Agriculture Department in 1919. In the beginning there were only three officers and the total budget was of Rs. 5,740. Gradually it developed into somewhat of a regular Department and by 1919 the budget was increased to Rs. 34,000. It had twenty-seven officers of the staff during the year 1931 and had a budget of Rs. 53,773.

The work of the Veterinary section comprised of the following:

(i) Treatment of animals at the hospitals of Gwalior, Ujjain and Guna and in the districts through the intermediary of 20 touring Veterinary Assistants.

(ii) Besides attending to outbreaks of contagious diseases and the treatment of cattle for simple ailments, Veterinary Assistants were also entrusted with the work of castrating undesirable animals in their territories.

(F) Dairy and Bull-Breeding Farm

In order to encourage cultivators for raising good animals, provision was made for raising bulls, by establishing a small herd of Haryana cows at the Central Experimental Farm, Gwalior, in the year 1922.

The Dairy and Bull Breeding Farm at Maharajpur which continued to run for a number of years as a commercial concern, under the trade department was under Darbar's orders been transferred to the Department of Agriculture.

Since September 1928, both bull farm and the Dairy as a matter of convenience been amalgamated and were placed under a trained officer.

The principal objective of the Dairy and Bull Breeding Farm were as follows:

1. To supply pure milk and milk products to the Palace, State Institutions and to the public.
2. To take up the work of breeding dairy and draft cattle for increasing milk yielding capacity in females and work efficiency in the males (bullocks).

   The work was concentrated to breeding of two or three well-known Indian breeds such as:

   (1) Haryana (Figs. 1 & 2

   (2) Sindhi (Figs. 3 & 4)

   (3) Montgomerry.

1. Haryana herd was established with the objective of producing prepotent bulls for improving draft animals in the Northern parts of the Gwalior territory.
2. Production of pure bred dairy animals of high yielding capacity was object of maintaining the Montgomerry breed.
3. A small herd of Sindhi cows was also established. As females of this breed were well known to be heavy milch yielders, breeding operations for that objective was taken in hand with these animals.

For dairy side purely, some buffaloes of Murrah type (Figs. 5 & 6) were purchased from the Punjab. The dairy by selection and breeding tried to improve the milk-yielding capacity of these fine animals.

Systematic and accurate records of each animal of these herds were maintained, so as to enable to eliminate undesirable and low yielding animals particularly those not coming to the required mark.

Besides maintaining these animals the question of feed and fodder was studied to find out cheap and nutritious kinds of fodder, suitable for the dairy animals.

In order to encourage cultivators and Zamindars to breed their cows with pure bred bulls, arrangements were made to raise young bulls of Haryana type at Maharajpur Gwalior, and of Malwi type at the Central Farm, Ujjain.

Fig. 1. Haryana Bull

Fig. 2. Haryana Cow

Fig. 3. Sindhi Bull

Fig. 4. Sindhi Cow

Fig. 5. Murrah Buffalo - Bull

Fig. 6. Murrah She Buffalo

(G) Agricultural Engineering Section (including boring)

This Sectionwas first started as part of the Agriculture Department in the year 1916. The same was transferred to the Trade Department in the year 1919. It had a staff of two Principal Officers and a budget of Rs. 31,896. In the year 1924, it was again brought under the control of the Agriculture Department. It has passed through various stages since then and many changes had to be made to make it really useful to the cultivators.It had four Principal Officers during the year 1931 and had a budget of Rs. 43,430.

In the boring line beginning was made with one machine in the year 1919, it had four power and three handsets during the year 1931 for working principally in the Districts of Tawarghar (presently district Morena), Esagarh (presently Guna) and Gird-Gwalior.

This section was initially started with the following objectives:

1. Sale of implements and machinery.
2. Contract of ploughing and threshing by means of power machinery.
3. Boring.

During the year1931, the activities of power ploughing were centralised in the Districts of Esagarh and Bhilsa (presently district Vidisha). Threshing of wheat was done in Bhilsa but no work was done in this line since 1926, evidently on account of unfavourable conditions.

In the boring section, there were 4 engine power and 3 hand power sets during the year 1931. Most of the work with these machines was done at that time in the Districts of Tawargarh, Esagarh and Gird-Gwalior. Power sets were used for hard rocks, whereas hand sets were used for soft stratas (Pandya, 1931).

(H) Institute of Plant Industry, Indore

The Institute of Plant Industry, Indore, was established in 1924 with the object of carrying out, "investigation on all matters relating to the production of raw cotton in India" and "agricultural development of States in Central India". As such, the programme of research at the Institute laid special emphasis on the study of genetics and botany of cotton. In addition to the improvement of crops and cultural practices of the tracts whose needs it catered for *viz*., Central India and Rajputana (now Madhya Pradesh and Rajasthan).

The farm was 300 acres in area, and while the soil varied from place to place, it is typical of the black cotton soil of the Malwa plateau. Out of

this area, 232 acres was under cultivation and the rest under paddocks, roads and buildings. Out of the cultivated area about 80 acres was allotted for experimental work to the scientific section and the rest, *i.e.*, about 152 acres were utilised for commercial farming and seed multiplication.

An excellent range of buildings consisting of cattleshed, godowns, stores, workshop and a small ginnery was provided. In addition to quarters for the farm staff and labourers, few quarters were built for housing the officers, who used to be deputed by the contributing States for different courses of studies on the farm.

Functions of this farm were:

(1) research on different ropswith a view to evolve new strains suitable for different regions of the State, particularly Malwa,

(2) demonstration and teaching,

(3) production of improved seed and their multiplication through the Department of Agriculture and

(4) supply of improved agriculture implements and tools.

Research schemes sanctioned at the Station

There were about 10 schemes sanctioned by different Institutes and Commodity Committees in operation at the Institute. Their names along with financing are as under:

1. Cotton physiological research scheme, Indore (Indian Central Cotton Committee).
2. Nimar cotton improvement scheme. (I.C.C.C.)
3. Scheme for breeding long staple American cotton for southern tract of Madhya Bharat (I.C.C.C).
4. Technological research scheme (I.C.C.C.)
5. Co-ordinated wheat rust control scheme (I.A.R.I.).
6. Scheme for disease resistance in linseed for Malwa (I.C.C.C.).
7. Co-ordinated crop weather scheme (I.C.C.C.).
8. Cotton survey scheme for Malwa (I.C.C.C.).
9. One-year Diploma Course in Agriculture, Horticulture and Animal Husbandry for Gram Sevaks in Madhya Bharat (Madhya Bharat Government).
10. Scheme for training in soil erosion and improved agricultural methods to Adivasi boys in Madhya Bharat (Madhya Bharat Government).

III. SALIENT ACHIEVEMENTS

(A) General (Agricultural Development etc.)

Projects Started during 1917-18

Dr. L.A. Kenoyer, Economic Botanist, Department of Agriculture, Gwalior Government started 10 projects during 1917-18. He detailed the outline of these projects as mentioned below (ARDA, 1917-18).

Project 1: Water Conservation by Tillage

Purpose: To determine the relative influence upon yields of different farm implements and of different treatments on the crop yields.

A. In 2 ½ acre land just to the right of Dr. Howard's wheat land, 5 plots (½ acre each) were treated as follows:

   1. Plough with tractor disc during the rains whenever soil is in right condition for working.
   2. Plough with tractor and disc just before planting.
   3. Plough with country plough and disc just before planting.
   4. Plough with Sabul plough and disc just before planting.
   5. Plough with country plough just before planting not discing.

   Plant gram in one-half and linseed in the other half of each plot.

B. Repeated with the same plots in 1919 planting Jowar. Plant Jowar in rows for cultivation and til during the growing season. Same crops were compared when sown by broadcasting method. In 1918 it was carried out in two 1 acre areas of the silage tract.

Project 2: Weed Investigation

A study of the weeds, destructive to crops, was done for identification, description, and their drawings also were studied, notes were prepared on distribution and means of eradication.

Special attention was paid to the eradication of *Ber* on the Central Farm and of *Kans* in the southern portions of the State.

This was done with the purpose to issue a booklet on weeds in the subsequent year. The booklet will contain plates and keys to make identification easy.

A book entitled "WEED MANUAL OF GWALIOR STATE and adjacent parts of India " was written by L.A. Kenoyer, Assistant Director of Agriculture, Gwalior State and published in 1924. This work was commenced in 1918 when the writer was in the service of the Agriculture Department of Gwalior State. It includes most of plants likely to be troublesome as weeds not only in Gwalior State but in the adjacent parts of North Central India; i.e. the United Provinces, the Central Provinces, Rajputana and the other states of the Central India at that time.Weeds, which were prevalent in Gwalior region at that time, are listed in Appendix No. III (Kenoyer, 1924).

Project 3: Plant Disease Investigation

A study of diseases destructive to farm and garden crops was undertaken. It included work on sugarcane diseases, wheat rust and a number of other crops and diseases. This was to prepare a bulletin describing all of the principal plant diseases.

Project 4: Insect Pest Investigation

A study of insects which damage farm and garden crops was planned to be conducted.

Insects were collected and their control measures were studied for a bulletin writing.

Project 5: Preliminary Soil Survey

Samples of soils were collectedfrom a number of localities and studied by Dr. Pendelton, Soil Scientist.

Project 6: Preliminary Crop Survey

It was planned during winter of the 1918-19 for :

a. Study of the distribution of crops in various sections with a view to recommend a better distribution.

b. Selection of suitable types and varieties of the field crops for improvement and general introduction.

Project 7: Testing of Sugarcane

Varieties weretried extensively and analysed for percentage of sugar in the Laboratory. The object was to determine the best and highest yielding varieties for the Gwalior region. The most promising varietieswere tried in other parts of the State also.

A small beginning was made by planting on Central Farm a number of sorts received from Dr. Barber and Prof. Knight.

Project 8: Testing and Breeding of Cotton

Different sorts including some choice types received from Prof. Gammie were tested on the Central Farm and on the Shajapur Demonstration Farm. Varieties were crossed in the effort to find a type combining adoption to climate, larger yields and good fibre.

Project 9: Selection and Breeding of Oilseeds

Various types of the different oilseeds were analysed in the Laboratory for content of oil. The higher yielding sorts with increased oil yield were selected.

Project 10: Bacteriology of Central Farm Soil and other Soils

Soil of Central Farm was analysed month by month during a year to determine:

(i) variation in number of bacteria in surface soil,

(ii) variation in number of bacteria in sub-soil,

(iii) effect of irrigation and cultivation on bacterial activity and on fertility.

(iv) influence of white-ants on bacterial activity and on fertility and

(v) comparison of bacterial activities of Central Farm soil with those of other soils in the Gwalior region.

Silage preparation from grasses and weeds

The failure of the rains and consequent lack of grass and fodder caused grievous suffering and mortality among the cattle. When things were very bad the question of silos was discussed and plans were drawn up to put them all over the State. Two tests were made, one at Surwaya village in an old unused well. The other in the Residency compound at Morar.

The following grasses and weeds were put in at Surwaya:

Panwara, Nib, Bar, Kasudan, Sitaphal, Arajhara, Chaurai, Gokharu, Biskapro, Gudni, Chirachata, Piyabansi, Ban, Inni, Maso, Thuwar, Banbai, Ghans, Jhalbiliya, Kakora, Bhatakatari, Khireti, Anjir, Nil, Tipni, Dub, Chhiranto, Banjura Ghans, Kingauwa, Tilbhonwara, Sirsi, Tilthuwa, Karijiri, Gandhera, Kamra, Ghamra, Ber and Sandal and the cost incurred was Rs. 19.85. The Silo was opened on April 28, 1919.

The following grasses and weeds were put in at Residency:

Dub hard, Farphota, Lalar, Balkada, Jawar, Kateri, Andh Zada, Sisum, Bajra, Pawar, Nonia, Akaua, Arhar, Choulai, Berjar, Lahsua, Mung Viskhapra Makka, Dudhi, San, Gulali, Kankaua, Badki, Patti with fruits, Ambadi, Tiltua Gokharu and Gondra, and the cost incurred was Rs. 135/- the silo was opened on April 10, 1919.

The Demonstrator at Surwaya took off the top which had been exposed to the air and was mouldy and rotten. He then reported that the silage was bad. He was ordered to continue to take the silage out and he then discovered that just below this top mouldy layer the silage was good and was eaten with avidity by the cattle.

The silo at the Residency was opened in the presence of the Resident, the Director, the Assistant Director Northern Circle, and the Demonstrator, on April 10, 1919. There was not more than two inches of waste. Below this the silage was good and has been regularly fed to the Central Farm oxen.

Now in a year when it was almost impossible to get any green thing that cattle would eat, it was most encouraging to find that after the chemical action of the silo so many otherwise impalatable and harmful weeds were turned into good fodder serves as a fodder bank or reserve of great value.

The Department planed a programme of putting in a few silos in every District under the direction of the Demonstrator. Over a large part of the State the silo was the cheapest and most effective fodder reserve possible (ARDA, 1918-19).

Influenza Epidemic in 1918-19

The Influenza Epidemic (Table 1) was a most serious set-back to agricultural operations. It prevented proper preparation of seed bed and delayed sowings in many cases. In others the cattle got into the fields and as there was no one to watch them, they did serious damage to the

standing crops of Juar, Bajra, Sugarcane and Cotton. The loss of the agricultural population was felt for years.

Table 1: Demonstrators reported deaths due to influenza in their villages as follows:

S. No.	Name of District	Name of village	Deaths due to Influenza	Total Population	Per cent
1.	Gird	a. Jaderua	75	627	13%
		b. Chak Behta Jagupura	3	-	-
2.	Bhind	Pipandi	121	743	16%
3.	Bhilsa	Amachawar	19	-	-
4.	Shajapur	Bhugor	23	204	11%
5.	Ujjain	Gondia	39	129	30%
6.	Isagarh	a. Mahuakheri	6	-	-
		b. Mirkabad	32	411	15%
		c. Ratbhanpura	23	-	-
7.	Narwar	Surwaya	50	399	13%

Two Demonstrators: Mr. Bama Shankar of Isagarh and Mr. Kali Sahai of Sheopur; and two most promising State Agricultural Students: Mr. A.C. Banerji and Mr. Ghanshyam Das Upadhya also died due to this disease.

(B) Botanical Section

The work of this section comprised of the following:

1. Survey of principle crops of the State.
2. Collection, isolation and selection of pure types of important crops by studying them in the Laboratory plots before sending them out to Experimental Farms.
3. Introduction and acclimatization of better varieties of new crops to suit Gwalior condition

4. Study and isolation of pure types of principal crops with a view to breed improved varieties suitable for Gwalior and Malwa conditions.

Arhar (Pigeon Pea)

In all seven varieties of Arhar were tried at the Central Experimental Farm, Gwalior during the year, 1935-36. Of these selections Nos. G-2, G-3 and G-5 proved promising, which gave an yield of 17 to 20 maunds* and 30 seers* per acre (ARDA, 1935-36).

Eight varieties (R 15, R 51, C 17, C 21, C 120, G 6, G 7 and Local) were tried at the Central Experimental Farm, Gwalior during the year 1938-39. Out of these, R 15 produced maximum grain yield (9.3 maunds* per acre) followed by C 120, G 7, C 21, C17, Local and R 51. Variety G 6 was the lowest yielder (5.0 maunds* per acre) (ARDA, 1938-39).

Eight varieties (R 15, R 51, C 17, C 21, C 120, Early Variety, G 6 and G 7) were experimented at the Central Experimental Farm, Gwalior during the year 1939-40. Variety C 17 gave maximum grain yield (20 maunds* per acre) followed by G 7, R 15 and C 120, which were statistically at par. Early variety has yielded significantly lowest grain yield (6.0 maunds* per acre) as compared to all other varieties (ARDA, 1939-40).

Twelve different varieties from outside as well as from the districts were tried at the Central Experimental Farm, Gwalior during the year 1944-45. Out of these, Progeny No. 11, Local Sabalgarh, Progeny No. 7, A. 70, Local Jora, Local Badki-Sarai, Murawali and T. 16 were found promising (ARDA, 1944-45).

An experiment, to find out a high yielding and most suitable variety for the locality, was conducted at the Central Experimental Farm, Gwalior. The experiment proved significant at 1% level. Variety C. 17 has proved to be the best. The experiment was tried for three years and the results reveal that varieties C. 17 and G 7 have proved to be the best (ARDA, 1944-45).

Bajra (Pearl Millet)

In all 10 varieties of Bajra were experimented in the year 1926-27 at Central Experimental Farm, Gwalior. The yield varied from 27 lbs per acre of Bhitarwar variety to 65 lbs per acre of Bikaner one. While 55 lbs per acre was the average yield of Bhavnagar variety (ARDA, 1926-27).

Four varieties of Bajra were experimented for five years at Central Experimental Farm, Gwalior. Of these Akola variety produced maximum average yield (4 maunds* 16 seers*) followed by Baroda (4 maunds* 12 seers*), Bhavnagar (3 maunds* 38 seers*), and Punjab (3 maunds* 36 seers*) (ARDA, 1930-31& 1932-33).

Ten varieties namely Local, Bhavnagar (G.1), Nabha, Jam 1, A 1/3, C 7, E 37, E 54, E 59 and Pb. (awned) were tried at the Central Experimental Farm, Gwalior during the year 1934-35. Out of these, Local, Bhavnagar (G.1), Nabha, Jam 1, A 1/3 and C 7 performed better as compared to other varieties. Three varieties from Nithad (E 37, E 54 and E 59) practically failed, which were very low yielding (ARDA, 1934-35).

Of the seven varieties tried at the Central Experimental Farm, Gwalior during the year 1935-36, Jamnagar Giant gave the best performance. The average length of ear heads was 40″. Amongst other varieties Baroda (G-2) gave the highest yield of 14 maunds* and 20 seers* per acre (ARDA, 1935-36).

Six varieties (Baroda, Akola, Nabha, Jamnagar Giant, P.B. 1/3 and Local) of Bajra were tested at the Central Experimental Farm, Gwalior during the year 1937-38. The results indicated that varieties Jamnagar Giant and Nabha were statistically equal and significantly superior to all other varieties in respect of grain yield. However, in fodder productions all the varieties were statistically equal (ARDA, 1937-38).

Twelve strains of Bajra were studied for their yield potential at the Central Experimental Farm, Gwalior during the year 1944-45. Out of these, strains T. 16, Jora, Morena, T. 11, G.S. 61/21 and Nabha were found to be promising (ARDA, 1944-45).

*1 Maund = 37.324 kg *1 Seer = 0.9331 kg

Fig. 7. Birds scaring by Sling from a Pearl Millet field.

Barley

Three varieties (U.P. 251, Local and B 21) and seven Gwalior selections (G 1, G 4, G 10, G 15, G 18, G 17 and G 12) of Barley were experimented at the Central Experimental Farm, Gwalior during the year 1934-35. Among these, three Gwalior selections namely G 1(11 maunds per bigha*), G 4 (11 maunds 10 seers*) and G 10 (10 maunds*30 seers*) produced higher grain yield as compared to others (ARDA, 1934-35).

Altogether 7 varieties were tried under dry conditions at the Central Farm, Gwalior during the year 1935-36. Of these G-1A, G-20, G-31 and G-36B were the highest yielders. The yield varied from 22 maunds* 20 seers* to 23 maunds 30 seers* per acre (ARDA, 1935-36).

Castor

Selection Nos. 13, 14, 15 and 16 produced coloured decorative foliage and hence they seemed fitted for propagation in gardens as ornamental plants.

A new type of castor with the largest bean ever noticed was introduced under No. 23 (ARDA, 1921-22).

Cotton

After three years of continuous experiments it was found that sowing of Cambodia Cotton some time in the beginning of May gave good results. Highest yield obtained from this crop in the year 1925-26 was 13 maunds* 20 seers* per acre (ARDA, 1925-26).

Four varieties of Malwi Cotton namely, Malwi, K-22, Jalaun and Marwari were tried for their yield potential. Malwi Cotton, gave the highest yield per acre, but owing to its low ginning percentage the net profit realised per acre was less (ARDA, 1925-26).

Two spacing treatments i.e. rows at 24″ apart and 18″ apart were tried in case of Malwi Cotton during the year 1925-26 at the Central Farm, Ujjain. The results indicated that closer spacing was more profitable as compared to wider spacing (ARDA, 1925-26).

Of the five varieties of cotton (irrigated) i.e., JN-1, Cawnpore-American, 4F, 285 F and Cambodia were experimented, the first two had good stand and yielded 215 and 190 lbs per acre, respectively. In all seven varieties of cotton (dry) were tried. The crop stood quite green in its vegetative growth bearing flowers here and there till November. But due to continuous cloudy weather heavy shedding was caused as a result of which no ball was formed. Thus, dry cotton under Gwalior conditions was a total failure (ARDA, 1927-28).

In a varietal experiment, five varieties of cotton were tried at Central Farm, Ujjain with Malwi as a control variety. Although Rosea Cotton gave the highest yield of 9 maunds* and 5 seers* of kapas per acre against 6 maunds* and 34 seers* of kapas from Malwi. At that time it was debatable whether its increased yield combined with poor quality of lint can stand in comparison with low yield coupled with superior quality of lints possessed by Malwi (ARDA, 1927-28 & 1928-29).

In the manurial trial there were 16 plots of 0.1 acre each. Three check plots were introduced in each set at suitable intervals. The following manures were tried :

(1) Cattle-dung manure applied at the rate of 15 cart-loads per acre in hot weather.

(2) Cattle-dung manure applied at the rate of 5 cart-loads per acre in hot weather plus top dressed with Nitrate of Soda at the rate of one maund* per acre after the plants had attained the height of 6 inches.

(3) Bone-meal at the rate of 4 maunds* per acre drilled at the time of sowing.

(4) Karanj cake applied in the same manure as the Bone-Meal at the rate of 4 maunds* per acre.

(5) Bone-super applied in the same manner as the Bone-Meal at the rate of 4 maunds* per acre.

(6) Three unmanured plots in each set as a check.

All the treated plots showed the effect of application of manure in the form of increased yield of kapas. Cattle-dung manure applied singly has given the highest yield of kapas when compared with other unmanured plots. There is decided case in favour of the application of manure against no application of manure on cotton. Hardly any difference was noticeable in plots treated with Nitrogenous manures versus phosphatic manures (ARDA, 1927-28 & 1928-29).

In the sowing time trial of Cambodia Cotton conducted for a period of five years, it has been confirmed that the most suitable time for sowing Cambodia Cotton in Malwa is the first week of May (ARDA, 1927-28 & 1928-29).

Seven varieties of irrigated cotton experimented at Central Experimental Farm, Gwalior, of which Mollisoni and A-19 were newly introduced. The highest yield was obtained from the newly introduced A-19 of Aligarh, which recorded 10 maunds* 16 seers* or 832 lbs per acre. Irrigated cotton showed full hopes of their success under local conditions (ARDA, 1928-29).

Altogether 12 varieties of dry cotton were tried at the Central Experimental Farm, Ujjain during the year 1930-31. Of these Banilla, Verun 262 and Bani 306 imported during the year have shown good account of themselves as compared to Malwi in matter of yield (ARDA, 1930-31).

Five varieties of dry cotton. viz., J.N. 1, A-10, N.R., C-402 and Mollisoni were tried under varietal test at the Central Experimental Farm, Gwalior during the year 1930-31. The crop stood very well all throughout its period of vegetative growth, but due to lack of sufficient moisture bolls did not develop as they ought to be and get shrivelled without being opened fully. Again the attack of Pink Boll worm was also observed in serious form which also proved responsible for the failure of dry cottons. However, the results of trials indicated that the yield of all the varieties were poor in general. The maximum yield was obtained in

case of A-19 (2 maunds 6 seers*) followed by C-402 (2 maunds 25 seers*), N.R. (1 maunds* 35 seers*), Mollisoni (1 maunds* 22 seers*) and J.N. 1 (1 maund*) (ARDA, 1930-31).

In the case of manurial tests conducted at the Central Experimental Farm, Ujjain. F.Y.M. at 15 cart loads per acre and F.Y.M. 5 cart loads plus Sodium Nitrate at 2 maunds* per acre have given an yield of 9 maunds* 15 seers* and 12 maunds* 5 seers* per acre, respectively. These two manures have also been found to give high yield even for an average of five years (ARDA, 1930-31).

Experiments on the manurial treatment of cottons were concluded with the recommendation that application of Sodium Nitrate and F.Y.M. drilled while sowing gave on the average good result and the cost of manure applied was fairly paid by the increased outturn (ARDA, 1931-32).

Of the three varieties of irrigated cotton tried at the Central Experimental Farm, Gwalior during the year 1935-36. Cambodia Cotton give the highest yield of 9 maunds* per acre (ARDA, 1935-36).

Altogether 12 varieties were tried at the Central Experimental Farm, Ujjain during the year 1935-36. Cottons introduced from Central Provinces and Bombay Presidency such as Banilla, Bani 306 and B-21 gave a much higher yield than the local ones. Seven varieties of cotton i.e. Cawnpore 520, Roseum, Malwi-1, Malwi-9 and Farm selection Nos. G-16 and G-51 were also tried in replicated plots as recommended by the Institute of Plant Industry, Indore; G-16 gave the highest yield and of the Indore strains, Malwi-9 was the second best giving an yield of 429 lbs of seed cotton per acre (ARDA, 1935-36).

Four varieties namely G 16, 43F, Mollisoni and V 434 were tried against Local as control at the Central Experimental Farm, Gwalior during the year 1937-38 under irrigated conditions. Variety Mollisoni recorded the highest yield, but it is short stapled, slightly coarse and low in ginning percentage. Variety 43F is better in stated land. Varieties G 16, 43F and Local were statistically equal (ARDA, 1937-38).

Six varieties (V. 434, E.B. 31, V. Bulk, Dokras 11, G 16 and Local) of cotton were tried at the Central Experimental Farm, Ujjain during the year 1937-38. From the point of yield per acre of seed cotton G 16gave the highest yield followed by Local and V. Bulk. G 16 was superior to all other varieties in respect of germination, yield and ginning percentage,but, poor in staple length (ARDA, 1937-38).

Five varieties of cotton namely Cambodia, 4F, 98, Egyptian 2, Egyptian 4 and G 16 (Local Farm) were tested at the Central Experimental Farm, Ujjain during the year 1938-39. The results indicated that variety G 16 (2.44 maunds* per acre) gave highest yield, which was significantly higher than all other varieties (ARDA, 1938-39).

Six varieties (Mollisoni, 43 F, L. SS, KT 289 F, Cwn 520 and Local) of cotton were tried at the Central Experimental Farm, Gwalior during the year 1939-40. Variety L. SS. Produced maximum yield of cotton (14.8 maunds* per acre) followed by 43 F, KT 289 F, Mollisoni and Cwn 520. Local variety produced significantly lowest yield (6.8 maunds* per acre) as compared to all other varieties except KT 289 (7.7 maunds* per acre) (ARDA, 1939-40).

Six varieties (V. 434, E.B. 31, Verum Bulk, Malwi 9, G 16 and Local) of cotton were tested at the Central Experimental Farm, Ujjain during the year 1939-40. The differences between varieties in respect of yield were non-significant, however, Malwi 9 and V. 434 produced higher yield as compared to other varieties (ARDA, 1939-40).

Five varieties (Verum 434, E.B. 31, Verum Bulk, Malwi 9) were compared with the local improved G 16 for yield of seed cotton at the Central Experimental Farm, Ujjain during the year 1940-41. The experiment was significant. Variety E.B. 31 has given the lowest yield (4.50 maunds* per acre) and was significantly inferior to the rest, which were all equal in their yielding ability (ARDA, 1940-41).

An experiment, to establish a variety of cotton most suitable to the locality under dry rainfed conditions, was conducted at the Central Experimental Farm, Gwalior during the year 1944-45. Varieties L.S.S. and Cambodia gave best yields. Cambodia was superior in staple length, while L.S.S. had slightly better ginning percentage (ARDA, 1944-45).

An experiment, to find out the most suitable date of sowing for irrigated cottons in Harsi area, was conducted at the Harsi Experimental Farm, Bagwai during the year 1944-45. The results indicated that cotton sown on May 20, gave the highest yield. The second in order stood the crop sown on 4th June. The crop sown with monsoon gave poor yield (ARDA, 1944-45).

An experiment, to find out whether cotton crop in Malwa responds to pure or mixed sowings, was conducted at the Central Experimental Farm, Ujjain during the year 1944-45. Seed of varieties Cambodia cotton

and G 16 were mixed together before sowing in different proportions as below:

A. Pure G 16

B. Pure Cambodia

C. G 16 (75%) + Cambodia (25%)

D. G 16 (50%) + Cambodia (50%)

E. G 16 (25%) + Cambodia (75%)

Treatment G 16 (75%) and Cambodia (25%) mixed together and sown has given the highest yield of cotton (2.34 maunds* per acre), but statistically equal to pure sowing of G 16 (2.27 maunds* per acre). Next in order stand 50:50 mixture of each G 16 and Cambodia. Pure Cambodia and 75% Cambodia mixed with 25% of G 16 have recorded poorest yields (ARDA, 1944-45)

Five dates of sowing (15th May, 31st May, 15th June, 30th June and 15th July) with variety C 402 of cotton were tested at the Central Experimental Farm, Gwalior during the year 1937-38 under irrigated condition. The results of the experiment show that the crop sown on 31st May gave the highest yield per acre(ARDA, 1937-38).

Gram

Experiments on gram threshing showed that the use of disc harrow reduces the cost of threshing to about 48% of the cost of threshing by bullocks (ARDA, 1921-22).

Gram varieties Pusa 17, Pusa 18, Pusa 24, Pusa 25 and local were experimented for their yield potential. The maximum grain yield was given by local (1282 lbs/acre) followed by Pusa 17 (1242 lbs/acre), Pusa 25 (1210 lbs/acre), Pusa 24 (1129 lbs/acre) and Pusa 18 (1066 lbs/acre) (ARDA, 1923-24).

Four varieties (Pusa-17, Pusa-18, Pusa-24 and Pusa-25) of gram were compared with local gram and the results for five years showed that Pusa-17 produced highest average yield (907 lbs per acre) followed by Pusa-18 (818 lbs per acre), local (785 lbs per acre), Pusa-25 (746 lbs per acre) and Pusa-24 (735 lbs per acre) (ARDA, 1926-27).

As stated in the last year's report, Pusa-17 has shown marked superiority over local gram as a result of six years' average (ARDA, 1927-28).

Eight varieties of gram such as C.F. Yellow, Pusa-17, Pusa-18, Pusa-24, Pusa-25, Malida, Malwi mixture and Gwalior local were tried at Central Experimental Farm, Ujjain. From the four years results obtained it has been found that mixtures have given very high yield. There seems to be some indication that one or more of the component types constituting the mixtures should be very prolific as otherwise the comparative low yields shown by C.F. Yellow grams cannot be accounted for. At any rate Malida stands superior to the rest of pure varieties included in the series (ARDA, 1925-26, 1926-27, 1927-28 & 1928-29).

The results of the last three years experiments (1926 – 29) on seed rate and spacing of gram indicated that 9″ spacing between row to row and 60 lbs per acre seed rate proved best (ARDA, 1926-27, 1927-28 & 1928-29).

Sixteen local selections of gram were tested at the Central Experimental Farm, Gwalior during the year 1930-31. Out of these, 8 selections namely local selections No. 4, 5, 9, 10, 11, 12, 15 and 16 produced higher yield and proved promising as compared to other selections (ARDA, 1930-31, 1931-32& 1932-33).

In the spacing test conducted at the Central Experimental Farm, Ujjain during the year 1930-31, the results indicated that 12″ between row to row has given best yield. As the seed rate test in gram 50 lbs per acre has given higher yield (ARDA, 1930-31).

The lower seed rate of 25 seers* per acre is associated with higher yield and, thus, results in a duplicate gain to the cultivator (ARDA, 1931-32).

In all 25 selections were tried at the Central Experimental Farm, Gwalior during 1934-35. Out of these two selections namely G 1 and G 8 have given yield of 4 maunds* 15 seers* and 4 maunds* 35 seers* per bigha*, respectively. Looking to six years results, G 10 and G 16 have been found to be the best yielders suitable for Gwalior Division (ARDA, 1934-35).

Of the 17 Selections of gram tried at the Central Experimental Farm, Ujjain during the year 1935-36, Nagpur 28 was the earliest, and gave the highest yield of 8 maunds* 15 seers* per acre. This gram however fetched lower price than Malida in the market(ARDA, 1935-36).

Ten varieties (G 16, G 9, G 10, G 17/A, G 18/B, G 20, G 36, G 37, G 14/A and Local) of gram were tried at the Central Experimental Farm,

Gwalior during the year 1937-38. The results indicated that variety G 36 produced highest grain yield. However, all the varieties were at par in respect of grain yield (ARDA, 1937-38).

Eight varieties (G 3A, G 66, G 69, G 75, G 78, G 79, P 17 and Local) were tested at the Central Experimental Farm, Gwalior during the year 1938-39. The crop wilted and ripened prematurely resulting in poor development of grains and hence the yields were greatly affected. Statistically all the varieties were at par, however, varieties G 66 (5.7 maunds* per acre), G 69 (5.1 maunds* per acre), G 79 (5.5 maunds* per acre) and Local (5.2 maunds* per acre) proved better(ARDA, 1938-39).

Four dates of sowing (24th October, 8th November, 24th November and 8th December) were tested in case of gram variety Malida at the Central Experimental Farm, Ujjain during the year 1938-39. The results indicated that 8th November (5.31 maunds* per acre) and 24th October (5.15 maunds* per acre) were statistically equal and distinctly superior to 24th November (4.23 maunds* per acre) and 8th December (2.83 maunds* per acre) in respect of grain yield. Hence it may be concluded that Malida variety of Gram when sown on 24th October or 8th November gave the better yield (ARDA, 1938-39).

Nine varieties (Malwi Yellow, G 16, Malida, Sarbati, Nagpur, Poona, P 58, Local and U.P.T. 7) were tried at the Central Experimental Farm, Ujjain during the year 1938-39. Poona and G 16 varieties have both given higher yield than Local. Malida was significantly lower in respect of grain yield production. Straw yield was not significantly affected by different varieties (ARDA, 1938-39).

Nine varieties (G 16, G 9, G 10, 17A, 18B, No.20, No. 36 B, No. 37 and 14 A) were tested at the Central Experimental Farm, Gwalior. The varieties 17 A and 36 B have out yielded all other varieties but were statistically equal to 18 B, 37 B, G 10, G 16 and 14 A (ARDA, 1939-40).

Four dates of sowing (15th October, 31st October, 15th November and 30th November) were tested with Gram variety C.F. Yellow at the Central Experimental Farm, Ujjain during the year 1939-40. The results indicated that 15th October (10.24 maunds* per acre) and 31st October (9.70 maunds* per acre) are statistically at par and significantly superior to 15th November (7.51 maunds* per acre) and 30th November (5.70 maunds* per acre) in respect of grain yield (ARDA, 1939-40).

Nine varieties (G3A, G66, G69, G75, G78, G79, G16 and P17) of Gram were tested at the Central Experimental Farm, Gwalior during the

Year 1940-41. The results revealed that variety G75 is the highest yielder and superior to G3A, G69, and P70. Variety G3A is the lowest yielder (ARDA, 1940-41).

Four varieties of Gram viz., C.F. Yellow, Malida, Sharbati and No. 78 were tried at the Central Experimental Farm, Ujjain during the year 1944-45. Variety Malida out yielded all the varieties recording 9 maunds* 10 seers* per acre. Variety No. 78 stood second and C.F. Yellow 3rd recording 6 maunds* 36 seers* and 6 maunds* 34 seers*, respectively (ARDA, 1944-45).

An experiment, to find out which variety of Gram gives the highest yield under Bhilsa conditions, was conducted at the Bhilsa Farm during the year 1944-45. Seven varieties were tried with C.F. Yellow as control. The varieties, White Small, Green Gram, G 16, Pink and C.F. Yellow stand in order as indicated by the grain yield. White Small recorded the highest yield of 8 maunds* 5 seers* per acre and Green Gram recorded 8 maunds* 4 seers* per acre (ARDA, 1944-45).

An experiment, to decide the most suitable date for sowing of Gram under Bhilsa conditions, was conducted at the Bhilsa Farm during the year 1944-45. Five sowing dates beginning from 20th October at an interval of a week, were kept in the trial. The crop sown on 20th October gave the highest yield of 2 maunds* 6 seers* per acre, while the crop sown on 18th November recorded 2 maunds* 2 seers* middle sowing dates recorded lower yields (ARDA, 1944-45).

Groundnut

Five varieties namely Big Japan, Small Japan, Spanish Peanut, Virginia Bunchand local groundnutwere experimented for their yield potential. Variety Big Japan gave maximum yield (2063 lbs/acre) followed by Virginia Bunch (1523 lbs/acre), Small Japan (1097 lbs/acre), Local (1070 lbs/acre) and Spanish Peanut (993 lbs/acre) (ARDA, 1923-24).

Out of four varieties (Virginia Bunch, Small Japan, Spanish Peanut and Big Japan), the average yield for six years trials indicated that Virginia Bunch yielded maximum followed by Big Japan, Spanish Peanut and Small Japan (ARDA, 1922-23 to 1927-28).

Six outside strains, two local and one control, in all nine varieties were tried at the Central Experimental Farm, Gwalior during the year 1944-45. Out of these varieties A.H. 11, A.H. 334, A. 2, B. 6, D. 3 and C.P. 10 proved promising in their yield potential (ARDA, 1944-45).

Six varieties of Groundnut namely A.H. 113, A.H. 334, C.P. 10, Small Japan, Spanish peanut and Local were tested at the Central Experimental Farm, Ujjain during the year 1944-45. Varieties A.H. 113 and A.H. 334, Local and C.P. 10, Spanish peanut and Small Japan were statistically equal among themselves. Similarly, Local and C.P. 10, Small Japan and Spanish peanut were also statistically equal. But A.H. 113 and A.H. 334 were significantly superior to the rest (ARDA, 1944-45).

Linseed

Five varieties namely Pusa T 124, Dhar White, C.P. (E.B. 3 Brown), White Farm Seed and Local Market Seed were tested at the Central Experimental Farm, Ujjain during the year 1938-39. From the results it was evident that Local variety and Dhar White were statistically equal. Similarly, Dhar White C.P. and White Farm Seed were also statistically equal. Local Market Seed was significantly superior to all, while Pusa T 124 is poorest(ARDA, 1938-39).

Six varieties of Linseed namely Pusa T 124, Dhar White, C.P. (E.B. 3 Brown), White Farm Seed, Cawnpore T 1193 and Cawnpore T 1206 were tried at the Central Experimental Farm, Ujjain during the year 1939-40. The results proved that the varieties C.P. (4.63 maunds* per acre), White Farm Seed (4.39 maunds* per acre) and Dhar White (4.36 maunds* per acre) were statistically equal and significantly superior to Cawnpore T 1193 (3.39 maunds* per acre), Cawnpore T 1206 (2.88 maunds* per acre) and Pusa T 124 (0.81 maunds* per acre) in respect of yield of seed (ARDA, 1939-40).

Six Varieties of Linseed namely Dhar White, Dhar Yellow, Dhar Red, C1150, C1193 and C 1206 were tried at Central Experimental Farm, Gwalior during the Year 1940-41. Variety C1193 produced significantly higher yield (5.6 maunds*/acre) than all other varieties. However, varieties Dhar White, Dhar Yellow, Dhar Red and C1150 gave statistically equal yield. Variety C1206 produced significantly lower yield (3.7 lbs/acre) as compared to all other varieties (ARDA, 1940-41).

Five varieties (Dhar White, E.B. 3, Farm White flower, Farm White pink flower and E.C. 1193) of Linseed were tested at the Central Experimental Farm, Ujjain during the year 1944-45. Varieties E.B. 3, Dhar White and Farm White were statistically equal. The experiment was conducted for four years and in all the previous years E.B. 3 and Farm White (white flower) varieties concurrently are better results (ARDA, 1944-45).

Paddy

Six varieties, viz., Kabri Mohor, T-136, K-184, Bansmati, Mushkan 41 and Kammod were tried at the Harsi Experimental Farm, Bagwai during the year 1940-41. This being the initial year the land was not adequately manured. In addition to this the transplanting was also delayed on account of the unworkable condition of the soil brought about by the incessant rains. Consequently the stand of the crop remained poor. The results in point of grain were significant, however, the yields were very poor. Varieties Kammod, Bansmati and K-184 were statistically equal. Bansmati, K-184 and Mushkan 41 were also equal in respect of grain yield. Kammod was significantly superior in yield to Kabri Mohor, T-136 and Mushkan 41 (ARDA, 1940-41).

A number of varieties were grown under dry conditions at the Central Experimental Farm, Gwalior during the year 1944-45. But the crop dried up due to drought. These trials were conducted in previous years also with similar failures. It was, therefore, concluded that paddy can't be grown as a dry crop under the conditions of the soils and rainfall prevailing on the Central Farm, Gwalior. Hence, further trials on paddy were stopped(ARDA, 1944-45).

An experiment, to find out a most suitable and high yielding variety of Paddy for Harsi area, was conducted at the Harsi Experimental Farm, Bagwai during the year 1944-45. The experiment was laid out in two parts, viz., one with a group of early varieties and the other with late varieties. Among early varieties, Banspatri has topped the list in respect of yield. Second in order stands T 136 which is statistically equal to Banspatri. Among late varieties, Kammod ranks highest in respect of yield, however, statistically at par with Kabri Mohor and Chinoor (ARDA, 1944-45).

The statistical examination of the results of five years' trials definitely revealed that the varieties Basmati, Banspatri and Kammod were the best varieties of fine, medium and coarse grains, respectively (ARDA, 1944-45).

Sorghum

In all 16 varieties of Sorghum were tried in the year 1926-27 at Central Experimental Farm, Gwalior. The average yield varied from 40 lbs per acre in case of Jaura to 950 lbs per acre in Cawnpore Dodania, while Mandraji, Sheopur and Andheri averaged for 360 lbs, 240 lbs and 320 lbs per acre, respectively (ARDA, 1926-27).

Four varieties of Sorghum namely Early Gird, Early Malwa, Andheri and Cawnpore Dodania were experimented at Central Farm, Gwalior during the year 1930-31. The results indicated that Cawnpore Dodania yielded maximum (10 maunds* 30 seers*) followed by Andheri (8 maunds* 30 seers*), Early Gird (8 maunds* 20 seers*) and Early Malwa (8 maunds* 20 seers*) (ARDA, 1930-31).

In all 8 varieties were tried at the Central Experimental Farm, Gwalior during the year 1935-36. Early Gird and Early Malwa gave the highest yield (ARDA, 1935-36).

Six varieties (Sheopur, C8B Double, C5 Double, C8B Single, C5 Single and Local i.e. Market Seed) of sorghum were tried at the Central Experimental Farm, Gwalior during the year 1937-38. From the results, it was evident that varietyC5 Double gave highest yield, however, statistically at par with Local, C8B Double and C5 Double. C5 Double was significantly superior to Sheopur and C5 Single. In respect of fodder yield C5 Double, C8B Double and C5 Single were statistically equal (ARDA, 1937-38).

Six varieties (Nilwa, Sundia, Sheopur, C8B Single, C5 Single and Local) of fodder Jowar were tried at the Central Experimental Farm, Gwalior during the year 1938-39. Variety C8B (96.4 lbs per acre green fodder) out yielded all the varieties but statistically at par with Sundia, Sheopur and C5 Single (ARDA, 1938-39).

Six varieties (Jamdhad, White Bundhel, Yellow Bundhel, Telia Bundhel, Saoner and Local) of grain Sorghum were tested at the Central Experimental Farm, Ujjain during the year 1938-39. As regards grain yield, the differences wereinsignificant, however, variety Saoner produced maximum grain yield (6.1 maunds* per acre) and variety Jamdhad gave minimum grain yield (3.3 maunds* per acre) (ARDA, 1938-39).

Six varieties (White Bundhel, Yellow Bundhel, Nilwa, Jamdhad, Saoner and Local) of fodder Sorghum were tested at the Central Experimental Farm, Ujjain during the year 1938-39. The results indicated that the variety Saoner was the most outstanding one from point of fodder yield (80 maunds* per acre), while varieties Yellow Bundhel and Local were statistically equal and Yellow Bundhel, Local and White Bundhel were significantly superior to Jamdhad and Nilwa (ARDA, 1938-39).

Five varieties (Nilwa, Sundia, Sheopur, C8B Double and C5 Single) of fodder sorghum were tested at the Central Experimental Farm, Gwalior during the year 1939-40. Variety C8B Double (195.2 maunds* per acre) out yielded all other varieties in respect of fodder yield. Statistically Sundia, Sheopur, C8B Double and C5 Single were all equal and significantly superior to Nilwa (under 16.6 maunds* per acre) (ARDA, 1939-40).

Six varieties (White Bundhel, Yellow Malwi, Nilwa, Jamdhar, Saoner and Market Local) of fodder sorghum were tried at the Central Experimental Farm, Ujjain. Treatments were statistically insignificant from fodder yield point of view. However, varieties Saoner (128.5 maunds* per acre) and Yellow Malwi (125.9 maunds* per acre) produced higher green fodder yield as compared to other varieties (ARDA, 1939-40).

Six varieties namely White Bundhel, Yellow Bundhel, Nilwa, Jamdhar, Saoner and Local of fodder Sorghum were tested at the Central Experimental Farm, Ujjain during the year 1940-41. The results indicated that variety Saoner produced maximum green fodder (108.54 maunds* per acre), but ripened a week later than White Bundhel (98.98 maunds* per acre) with which it was statistically equal (ARDA, 1940-41).

Eight strains of Sorghum were studied for their yield potential at the Central Experimental Farm, Gwalior during the year 1944-45. Out of these, 8B, 30C, Tall No. 5, J.B. 1, J.B. 6, and C 8B Double strains proved promising in respect of grain yield (ARDA, 1944-45).

Soybean

Three varieties of Soybean namely Small Yellow, Small Brown and Small Green were tried for their grain yield potential at the Central Experimental Farm, Ujjain during the year 1940-41. The results were significant. Varieties Small Green (6.75 maunds* per acre) and Small Brown (6.28 maunds* per acre) were statistically equal and superior to Small Yellow (5.66 maunds* per acre) (ARDA, 1940-41).

Sugarcane

During the year 1918-19, sugarcane was planted according to the Poona system, in Garden Plot No. 2. Before planting, the whole area was ploughed and manured with cow-dung at the rate of 50 maunds* per bigha* and with castor cake at the rate of 25 maunds* per bigha*. Trenches were dug 5 feet apart. In the second week of February 1919, the Sugarcane varieties Dhor, Chin, Saretha, Khairee, Sonabali, Java 246 and 247 from the **Rairu Sugarcane Farm of the GwaliorTrust** were

planted. Excepting Dhor and Chin, the tip leaves of all other varieties dried owing to the excessive heat of this locality (ARDA, 1918-19).

Ten varieties of Sugarcane were experimented for their yield potential. Of these varieties, A-42 and Co. 205 proved high yielders under Gwalior conditions (ARDA, 1925-26).

An experiment was conducted during 1924 to 1926 with the objective to study the time of maturity of 12 sugarcane varieties. As a result of this experiment it was found that the time of maturity varied. Sowing was done in April and it was found that the most appropriate time for cutting was in March and of some in the middle of January even (ARDA, 1926-27).

Twelve varieties were under trial of which Co. 213, Co. 221 and Manjav were introduced from Bhopal during the year1927-28. Manjav being a thick variety was greatly damaged by white ants. From the periodical sucrose tests made at the Laboratory it was found, that most of the canes ripened at 10 ½ to 11 ½ months from the date of sowing. POJ-36 and Co. 205 yielded 3,872 and 3,147 lbs of gur per acre (ARDA, 1927-28).

The objective of the experiment was to study the ripening time of sugarcane in general. The experiment was initiated in 1925 and completed in 1927. As a result of this experiment, it was found that in general a period between 10.5 to 11.5 months was required for proper ripening and highest percentage of sucrose (ARDA, 1927-28).

In all 8 varieties were experimented at the Central Experimental Farm, Gwalior during the year 1932-33. Looking to this year's results Co. 285 and Co. 290 gave the higher yield as compared to others (ARDA, 1932-33).

Altogether 4 thick and 7 thin canes were tried at the Undasa Farm during the year 1932-33. Three strains of cane x sorghum hybrid received from Coimbatore were also sown. Co. 213 gave very satisfactory results and gained popularity in some of the villages around Ujjain. It was a strain which was recommended for being hardy, high yielder and early maturing (ARDA, 1932-33).

The object of the experiment conducted in 1931 and 1932 was to utilize the canes left standing in the fields till late in the season. It was found that marked inversion had taken place in the juice. Alcoholic fermentation was first allowed to proceed to the maximum and then acetic fermentation was induced and allowed to proceed till there was no increase in acidity. As a result of this experiment, the vinegar was prepared from malt. The canes were left standing in the fields late in the seasons and could not be utilized for Gur making as Gur prepared from them was not of a good quality (ARDA, 1932-33).

Altogether 12 varieties were tried at the Central Experimental Farm, Ujjain during the year 1933-34. Thin canes were better off than the thick ones which required large amount of water for their growth. Of the thin canes Co. 213 established its merit as a superior type (ARDA, 1933-34).

Of the 12 varieties tried at the Central Experimental Farm, Gwalior during the year 1934-35, Co. 313, Co. 301, Co. 310 and Co. 290gave higher yield of gur (ARDA, 1934-35).

Six thick and six thin varieties of Sugarcane were experimented at the Central Experimental Farm, Ujjain. Of the thin varieties, Co. 213 proved frost resistant and also high yielder. Even though the crop was severely affected by frost, the yield of gur obtain from Co. 213 was 26 maunds* per bigha* (ARDA, 1934-35).

Twelve varieties (Co. 205, Co. 213, Co. 270, Co. 285, Co. 290, Co. 301, Co. 301, Co. 310, Co. 301, Co. 313, Chen, Machla and A 42) of Sugarcane were tried at the Central Experimental Farm, Gwalior during the year 1934-35. Of the 12 varieties tried, Co 313 (40 maunds* per bigha*) and Co. 301 (37 maunds* per bigha*) have given higher yield of gur where as Co. 310 (31 maunds* 35 seers*) and Co. 290 (31 maunds* 30 seers*) have stood equally in comparison in point of gur productions (ARDA, 1934-35).

The object of the experiment was to study the difference in the Gur made before and after frost attack. The experiment was performed during the severe frost attack and sugarcane after frost attack was studied and submitted for chemical analysis. The sucrose content in the Gur made before frost was 63.4%, while that made from canes after frost attack was 56.2%. There was a diminition of 7.2% in sucrose content with a corresponding rise in the reduce sugars, it was also found that Gur made from frost affected canes was inferior in respect of grain and was soft (ARDA, 1934-35).

A manurial experiment was conducted with Co. 285 variety of Sugarcane at the Central Experimental Farm, Gwalior during the year 1934-35. The quantity of manures applied was in accordance with the type of manure and their inherent nitrogen contents. The general nitrogen requirements of the cane crop were calculated at 300 lbs of nitrogen per acre. The results of the manurial trial on 1/40 acre with Co. 285 variety are presented in Table 2.

The results indicated that there is not much difference observed in yield of canes in both sodium nitrate and ammonium sulphate treatments. Both manures have practically equally acted upon the yield and only minor difference in results is seen. However ammonium sulphate with castor cake has maintained its position in giving the highest weight of canes (ARDA, 1934-35).

Of the 15 varieties tried at the Central Experimental Farm, Gwalior during the year 1935-36, two were thick canes and the rest were of thin canes. Thick canes were very much affected by white ants. From the average of five years figures Co. 290, Co. 301, Co. 312 and Co. 313 have given the highest yield (ARDA, 1935-36).

Table 2: Manurial treatment details and yield of canes.

S. No.	Type of Manure used	Quantity applied in 2 doses	Total yield of canes from 1/40 acre		Yield of canes per bigha*	
			Maunds*	Seers*	Maunds*	Seers*
1	No manure	Nil	11	33	236	20
2	F.Y.M.	1 ¼ cart load	12	10	245	0
3	F.Y.M. + Ammonium Sulphate	1 ¼ C.L.+ 37 ½ lbs	15	5	302	20
4	F.Y.M. + Sodium Nitrate	1 ¼ C.L.+ 50 ½ lbs	15	0	300	0
5	F.Y.M. + Castor cake	1 ¼ C.L.+ 187 ½ lbs	13	4	262	0
6	F.Y.M. + Ammonium Sulphate + Castor cake	1 ¼ C.L.+ 17 ½ lbs + 100 lbs	16	0	320	0
7	F.Y.M. + Sodium Nitrate + Castor cake	1 ¼ C.L.+ 24 lbs + 100 lbs	15	20	310	0
8	F.Y.M. + Niciphos	1 ¼ C.L. + 42 lbs	13	20	270	0

The object of the experiment conducted was to study the possibilities of introducing the use of “Activated Charcoal” from rice

husk for clarification of cane juice in the process of Gur making. The experiment was initiated in 1935 and completed in 1936. As a result of the experiment it was found that Gur obtained by using activated carbon was of a good white colour (ARDA, 1935-36).

Of the 13 varieties tried at the Central Experimental Farm, Ujjain during the year 1935-36. Co. 213 gave a fair average yield of 28 maunds* 4 seers* of gur per acre under the conditions prevailing at the Farm - where on account of scarcity of water the growth of sugarcane was very much retarded. This cane, however, as done well at cultivators field where irrigations facilities were plentiful (ARDA, 1935-36).

Nine varieties of sugarcane were tested at the Central Experimental Farm, Ujjain during the year 1936-37. Variety Co. 213, which till 1935-36 proved promising.But did not show good results during the year 1936-37. The newly added varieties Co. 312 and Co. 313 gained reputation elsewhere as high yielders (ARDA, 1935-36).

Seven varieties (Co. 300, Co. 301, Co. 312, Co. 313, Co. 331, Co. 385 and Co. 393) of sugarcane were tried at the Central Experimental Farm, Gwalior during the year 1938-39. The results indicated that Co. 300, Co. 301 and Co. 312 were statistically equal in Gur yield.both Co. 300 and Co. 301 were significantly superior to all other varieties. Varieties Co. 385, Co. 313 and Co. 331 were statistically equal. Though these three varieties were significantly superior to Co. 393 (ARDA, 1938-39).

Three varieties (Co. 213, Co. 313 and P.O.J. 2878) of Sugarcane were tested at the Central Experimental Farm, Ujjain during the year 1939-40. The experiment was proved significant from the point of yield of Gur. Variety Co. 313 produced significantly higher yield of Gur (92.44 maunds* per acre) as compared to varieties P.O.J. 2878 (68.91 maunds* per acre) and Co. 213 (66.90 maunds* per acre), which were statistically equal in yielding capacity of Gur (ARDA, 1939-40).

Comparative germination study of different portions of cane was conducted at the Central Experimental Farm, Gwalior during the year 1938-39. Four treatments (Top setts sowing, Middle setts sowing, Bottom setts sowing and whole cane sowing) were tested with variety Co. 312. The experiment was insignificant. However, taking mean into consideration, germination from Top setts showed the highest number of plants, whereas the number of canes were found to be more from middle setts (ARDA, 1938-39 & 1939-40).

An experiment was conducted with Sugarcane variety Co. 312 at the Central Experimental Farm, Gwalior to find out which method of

planting of Sugarcane gives the best yield and whether earthing up is necessary. The following treatments were applied:

A.Sowing cane in furrows with earthing up.

B.Sowing cane on Flat and earthing up.

C.Sowing cane on Flat and no earthing up.

The experiment proved significant. Treatment A gave significantly higher yield of canes (722.0 maunds* per acre) as compared to treatment C (509.3 maunds* per acre). However, at par with treatment B (593.3 maunds* per acre). Treatments B and C were statistically equal (ARDA, 1939-40).

Eight varieties of Sugarcane namely Co300, Co301, Co312, Co313, Co331, Co347, Co385 and Co393 were tested at the Central Experimental Farm, Gwalior during the year1940-41. A perusal of the summary of the results indicates that Co300, Co312, Co385 produced significantly higher yield than other varieties. However, Co300 and Co312 were statistically at par. Co300 was significantly higher yielder than Co385 (ARDA, 1940-41).

An experiment, to study the effect of planting in different months, on the ripeness and yield of canes, was conducted at the Harsi Experimental Farm, Bagwai during the year 1944-45. The crop was very poor due to damage by hailstorms. However, the results indicated that October and November sowings were better than the rest (ARDA, 1944-45).

Varieties.viz., Co. 213, Co. 300, Co. 301, Co. 310. Co. 312, Co. 313, Co. 347, Co. 381, Co. 385, Co. 393 and Co. 421 were tested at the Harsi Experimental Farm, Bagwai during the year 1940-41. Looking to the quantity of Gur yielded, the varieties Co. 300, Co. 301, Co. 331 and Co. 385 appeared promising. The Gur obtained from Co. 301 and Co. 310 which had an attack of smut, though black in colour, surpassed all other varieties in point of sweetness.

The objectives of the experiments conducted on sugarcane were to study the probable ripening time, the increase in the sucrose content during the ripening period and to find out the outstanding varieties on the basis of their sucrose content and other factors. The studies were initiated in the year 1938-39 and completed in 1941-1942, taking in an average 15.0% sucrose, which was the average for all varieties in the month of November as a starting point for maturity, it was apparent that six varieties only. viz., Co 381, Co 385, Co 393, Co 421, Co 313 and Co 331 attained maturity by November, i.e., in the 10^{th} month from sowing. Six varieties, viz. Co 301, Co 310, Co 347, Co 213, Co 300, Co 312 attained this minimum maturity by December, i.e., in the 11^{th} month from sowing. The maximum average sucrose percentage was taken at

20.0%, which was average for all varieties in the month of March on the 14th month from sowing. This was attained by only one variety. i.e., Co 385 by February and by five varieties Co 381, Co 310, Co 393, Co421, and Co 301 by March. Taking the average of 17.5% sucrose content, which was an average for all varieties for the whole period of five months of maturity. It was clear that out of the twelve varieties only six viz. Co 381, Co 385, Co 421, Co 393, Co 301 and Co 310 proved to be worth considering from the point of richness and even among these six varieties there was only one variety, viz. Co 381 which was outstanding(ARL, 1916-1952).

Wheat

Pusa No. 4, a new wheat variety was introduced in 1916-17 in Malwa Districts. This variety had the following points in its favour:

a. The yield was greater than the local varieties.

b. The growing season was less.

c. Competed with local varieties both on irrigated as well as unirrigated lands.

d. Fetched a better price in the market.

e. Seed selection, was very happy.

(ARDA, 1916-17)

Mr. A. Howard arranged to supply 3000 maunds* of seed of variety Pusa No. 4 of wheat for distribution to the farmers of Gwalior State. Unfortunately, after the best efforts of all concerned, owing to inability to secure railway wagons, only 900 maunds* seed of variety Pusa No. 4 of wheat arrived in the State. This seed was distributed to the farmers of Gwalior State (ARDA, 1918-19).

The Assistant Director of Agriculture, Southern Circle, Ujjain reported in the year 1921-22 that the scheme of work for solving our wheat improvement problems fall under the following heads:

(1) Enquiry about the wheat crop grown throughout the State.

(2) Selection of the indigenous varieties and strains cultivated.

(3) Introduction of new promising sorts to Gwalior State.

(4) Preliminary row tests of the local and foreign wheats.

(5) Multiplication of desirable varieties or strains.

(6) Trials in plots.

(7) Distribution of the seed of proved superior varieties.

For the sake of convenience, head (1) and (2) were dealt with conjointly, as work concerning both the items was carried out simultaneously. The wheat crop of the Bhilsa District was surveyed in the year 1921-22 and selections made. Nine botanical varieties were identified. Eight under the durum group and one under the vulgare group. Four of the durum wheats belong to the *kathia* subgroup, and the rest four to the *bangasia* subgroup. *Kathia* and *bangasia* of the Bhilsa Districts correspond to *ekdania* and *kalabal* subgroup of Ujjain and Shujalpur Districts.

Wheats growing under variety names *daudkhani* of Ujjain, *jalalia* of Bhilsa and *hansia* of Basoda were all identical and were much in favour for export trade. They were white hard wheats.The majority of farmers in Bhilsa Districts prefered to sow *khabda* which, correctly speakingwas a free mixture of white hard and red hard wheats.

(3) Forty varieties of wheat were imported from Coura, New South Wales, Australia. These were included in the preliminary row tests, and propagated to observe their behaviour under Gwalior conditions.

(4) Row tests were conducted at the Gwalior and Ujjain Experiment Stations in the year 1921-22.

(i) Work at Gwalior: Sixty three pure cultures of wheat from Northern Gwalior. 32 from Malwa (Southern Gwalior), 40 from Australia, 141 from the United States of America, and 12 of Standard Indian wheats, were grown in rows. Growth characters were observed periodically and other characters were subsequently examined in the laboratory.

Observations of growth characters like strength of straw, stooling, freedom from disease, resistivity to drought, maturity and shedding of grain helped in the selection of a variety. Each of the above characters influenced productivity. Presence or absence of beards, influenced its comparative liability to damage from birds and wild animals. Leaf development and chaff affected the fodder value. Seed appearance and size influenced the market value. However, there was no direct correlation between any of these characters and the yielding power of a wheat variety. A large collection and its comparative testing was essential from the beginning of such a project. In this year's row test, 31 cultures of North Gwalior, 17 of Malwa, 7 of Australian and 13 of the United States of America came out satisfactorily.

(ii) Work at Ujjain: Similar work carried out at Ujjain showed that 24 cultures were promising for dry-farming, and 38 for irrigated lands.

(5) The multiplication plots served as a connecting link between row tests and plot tests and offered an additional opportunity for eliminating undesirable sorts. One hundred and eight cultures were planted for multiplication but only 42 of them came to or exceeded the average standard. A few of the better ones were planted in one-tenth of acre plots for field trial.

(6) The results of the wheat sown in one tenth of acre plots are given in Table 3.All varieties, on the whole, yielded less than previously. Still Banda Sarbati and I.K. did well as before. Kalabal proved a good addition to the list. Early Defiance gave an increased yield in spite of an unfavourable season, perhaps illustrated a case of improvement through acclimatization. Punjab Nos. 8A and 11, spoken of high about their yielding power in their own province, performed below expectation. Sonora was noticed to be a late maturing variety running to straw. Less productive varieties were carried back to the multiplication plots and new promising ones were included in this series.

(7) Successful varieties were turned over to Experimental Farms and Demonstration Villages for seed production in bulk. Hitherto Pusa Nos. 4 and 12 were recommended for general adoption under irrigated or similar conditions. Theymade their own way in tracts where they proved their worth. The demand for Pusa 4 seed continued to the high. A few cases of poor results with Pusa No. 4 wheat were also reported.

The ultimate aim of all plant breeding work was to satisfy the needs of the farmers. These needs were determined by conditions given or created,in a large measure. Climate, rainfall and soil were conditions given. Cultivation, manuring and irrigation were conditions of creation. These working together constituted the crop environment. With a knowledge of these conditions, a farmer could choose an improved variety of wheat that best suited his conditions (ARDA, 1921-22).

Table 3: Statement of outturn and value of wheat as a outcome of varietal experiments 1921-22.

Plot No. (of the 0.1 acre plots)	Variety	Actual Results of 0.1 Acre Plots											
		Grain	Straw	Value of total produce			Cost of Production			Profit (Plus) or Loss (Minus)			
		lbs	lbs	Rs.	a.	p.	Rs.	a.	p.		Rs.	a.	p.
1	Soharia	100	232	10	9	4	10	13	0	minus	0	3	9
2	Banda-Sarbati	158	242	15	2	9	10	13	0	plus	4	5	9
3	I.K.	129	242	12	15	0	10	13	0	plus	2	2	0
4	Early Defiance	100	211	10	5	3	10	13	0	minus	0	7	9
5	Cawnpore No. 13	106	186	10	7	6	10	13	0	minus	0	5	6
6	Punjab No. 8A	84	162	8	7	6	10	13	0	minus	2	5	6
7	Punjab No. 11	88	168	8	13	19	10	13	0	minus	1	15	3
8	Pusa No. 12	115	165	10	14	6	10	13	0	plus	0	1	6
9	Sonora	100	100	10	13	6	10	13	0	plus	0	1	6
10	Kalabal	117	117	11	9	9	10	13	0	plus	0	12	9

Rs. = Rupees a = Aana P= paisa

Experiments on wheat threshing were carried on for a fortnight. In these experiments, threshing by bullocks treading was compared to threshing by disc harrow. The results obtained were very significant, and conclusively proved the superiority of the latter method as regards economy. Cost of threshing of 1,000 lbs (Grain and Bhusa mixed) by bullock treading come to Rs. 4.0, while cost of threshing the same amount by disc harrow was Rs. 9.75 *i.e.*, use of disc harrow for threshing reduced the cost of threshing, as generally practised by Zamindars and Kashtkars by about 60% (ARDA, 1921-22).

Wheat varieties Pusa 4, Pusa 12 and Cawnpore 13 were experimented for their yield potential. Pusa 4gave maximum grain yield (2181 lbs/acre) followed by Cawnpore 13 (1475 lbs/acre) and Pusa 12 (1394 lbs/acre) (ARDA, 1923-24).

In the varietal tests of wheat, 39 varieties were tried. Of these IK, GC-17, GV-7 and Kalabai gave a regular increase in the yield per acre (ARDA, 1925-26).

Three seed rates of 40, 45 and 50 seers* were tried in case of Malwi wheat during 1925-26. The results indicated that 50 seers* per acre gave higher yield as compared to other two seed rates (ARDA, 1925-26).

Of the sixteen varieties of dry wheat tried at the Central Experimental Farm, Ujjain, with Ekdania as a check variety G.D. 10 and G.D. 11 gave higher yield during three years (ARDA, 1926-27& 1927-28).

To study the effect of manuring on the weight of wheat grains. 100 grains of wheat produced under different manurial treatments were weighed. The different manurial treatments were:

1. Fertilizer mixture alone.
2. Farm yard manure alone.
3. Farm yard manure plus fertilizer mixture and
4. Blank.

The experiment was initiated in 1924 and completed in 1926. As a result of this experiment on wheat under different manurial treatments. It was found that the grains from the plot which had received F.Y.M plus fertiliser mixture were better developed and had more weights (ARDA, 1926-27).

Fourteen varieties were sown in $1/10^{th}$of acre plots. From the results of five years trial Pipandi white, Kalabal No. 4, G.D. 13, I.K., Banda Sharbati and Kalabal were found to yield 1,000 to 1,200 lbs per acre (ARDA, 1927-28).

Six varieties were taken under varietal tests to complete their five years record on 1/10th acre plots in the wheat nursery. Over and above this, a new series of varietal trial was started with Punjab and Pusa wheats on 1/50th acre plots. Kalabal No. 4 was heavily attacked by orange rust which reduced its yield, greatly. G.V. 4 recorded the highest yield of 18 maunds* 4 seers* or 1,452 lbs per acre. Next in order of yields were I.K., Federation soft., G.V. 18 and P. 52 giving 15 maunds*, 11 maunds* 35 seers*, 10 maunds* 25 seers* and 10 maunds* 10 seers* per acre, respectively. Of new wheats Punjab 11 recorded the highest yield of 6 maunds* 35 seers* per acre.Whereas, Punjab 17, Punjab 8/A and Pusa 8/5 recorded 5 maunds* 25 seers*, 2 maunds* 20 seers* and 6 maunds* 10 seers* respectively per acre (ARDA, 1928-29).

In an experiment conducted during 1927-1928. on manurial value of different parts of green manuring crop Sunnhemp was studied on wheat crop. The treatments were as under:

1. Whole green crop ploughed.
2. Roots only ploughed.
3. Tops only ploughed and
4. Blank.

From the results, it was concluded that the ploughing at tops were found to be the most beneficial and having a higher manurial value (ARDA, 1928-29).

The object of the experiment conducted during 1927-28 was to study the effect of organic manures and other practices like bunding and tillage in dry farming on wheat. As a result of this experiment, it was found that tillage and the use of organic manures such as green manuring and farm yard manure gave better result in dry farming conditons (ARDA, 1928-29).

The object of the experiment was to study the possibilities of water economy in wheat irrigation. The experiment was initiated in 1927 and completed in 1928. As a result of this experiment, the minimum number of irrigation could be limited to two in normal times (ARDA, 1928-29).

Eight varieties of wheat viz., Punjab 8-A, Punjab 11, Pusa 80-5, Pusa 52, Pusa 53, Pusa 100, Clarendon and Jondhalya were tested at Central Experimental Farm, Gwalior during the year 1930-31. Out of these, Clarendon, Punjab 8-A, Pusa 52, Pusa 53 and Pusa 100 proved promising as these varieties produced higher yield as compared to others (ARDA, 1930-31& 1932-33).

Of the 11 varieties tried at the Central Experimental Farm, Gwalior during the year 1935-36. K-808 gave the highest yield of 20 maunds* 10 seers*. It was also found to be early in heading and early ripening (ARDA, 1935-36).

Of the 13 varieties of wheat tried at the Central Experimental Farm, Ujjain during the year 1935-36. 9D of the Punjab proved not only been the highest yielder with 7 maunds* 5 seers* of grain per acre, but it also fetched a good price in the market (ARDA, 1935-36& 1936-37).

Thirteen varieties (B.S., I.K., P.W., P 100, P 53, P 52, P 101, P 111, P 114, P 165, 9 D, K 808 and Local) of wheat were experimented at the Central Experimental Farm, Gwalior during the year 1937-38. Variety 9 D produced highest grain yield, which was significantly higher than all other varieties except P.W. and K 808. Variety P 114 gave lowest grain yield (ARDA, 1937-38).

Eight varieties (G 45, G 47, G 85, Pb 8A, Pbc. 591, Pbc 518, C 13 and Local) of wheat were experimented at the Central Experimental Farm, Gwalior during the year 1938-39. Statistically all the varieties were similar in respect of grain yield. However, varieties G 85 (21.0 maunds* per acre), Pb 8A (21.0 maunds* per acre), Pbc 518(21.0 maunds* per acre) and Local (21.9 maunds* per acre) have yielded better (ARDA, 1938-39).

Eight varieties of dry land wheat (9D, G.D. 11, A.O. 90, A.O. 115, K 808,C.P. 168,C.P. 224 andLocal) were tested at the Central Experimental Farm, Ujjain during the year 1938-39. The results indicated that C.P. 168 was significantly higher yielding variety in point of grain production, while K 808 recorded lowest grain yield.however, at par with Local. Both from grain and straw point of view 9D surpassesed the rest (ARDA, 1938-39).

Five varieties (Pusa 52, Pusa 80, Pusa 101, Pusa 111 and Kalabal) of irrigated wheat were tested at the Central Experimental Farm, Ujjain during the year 1938-39. The mean values in respect of grain and straw yields per acre indicated that variety Pusa 101 proved higher yielder as compared to other varieties (ARDA, 1938-39).

Seed rate trial on wheat variety Pipandi White was conducted at the Central Experimental Farm, Gwalior during the year 1938-39 for testing five seed rates (60, 70, 80, 90 and 100 lbs per acre). Statistically all the seed rates were at par in respect of grain yield. However, seed rate 90 lbs per acre produced maximum grain yield (27.4 maunds* per acre) (ARDA, 1938-39).

Spacing experiment of wheat variety Pipandi White was conducted at the Central Experimental Farm, Gwalior during the year 1938-39 for comparing three spacing treatments (6″, 9″ and 12″ between row to row). The results indicated that the 9″ distance between row to row gave highest yield (ARDA, 1938-39).

Six seed rates (25, 30, 35, 40, 45 and 50 seers* per acre) were tested with wheat variety G.D. 11, at the Central Experimental Farm, Ujjain during the year 1938-39. The results indicated that there were insignificant differences between different seed rates in respect of grain yield, therefore no conclusion can be drawn in respect of seed rate for wheat (ARDA, 1938-39).

An experiment was conducted with 10 varieties (Banda Sharbati, I.K., Pipandi White, Pusa 100, P 53, P 52, P 101, P 111, 9 D and K 808) of wheat under irrigated conditions at the Central Experimental Farm, Gwalior during the year 1939-40. Variety K 808 (32.0 maunds* per acre) out yielded all the varieties. However, statistically equal to I.K., P 53, P 100, Pipandi White. Variety P 111(23.0 maunds* per acre) gave significantly lower grain yield as compared to all other varieties. However, statistically equal to 9 D (ARDA, 1939-40).

The experiment was conducted with P 100 variety of wheat at the Central Experimental Farm, Gwalior under irrigated conditions to ascertain, which of the practices of green manuring was most beneficial to the wheat crop. The green manuring treatments were as follows:

A.No green manuring.

B.Sunhemp (buried in Situ).

C.Only the root stalks of Sunhemp allowed to decay.

D.The portion of Sunhemp crop cut above ground in treatment C and buried.

Treatment B gave highest grain yield (1703 chhataks per acre) of wheat crop followed by treatment A (1637 chhataks per acre), treatment D (1611 chhataks per acre) and treatment C (1594 chhataks per acre). However, statistically all the treatments were equal in respect of grain yield of wheat (ARDA, 1939-40).

A manurial trial on wheat variety Pipandi White was conducted at the Central Experimental Farm, Gwalior during the year 1940-41. Five manurial treatments were tried as mentioned below:

A. No manure.

B. Cotton mill waste (15 lbs of Nitrogen).

C. Cotton mill waste (30 lbs of Nitrogen per acre).

D. F.Y.M. 20 cart-loads per acre.

E. Green manuring with Sunhemp.

Cotton mill waste with 30 lbs of Nitrogen per acre gave highest yield of wheat (11.5 maunds* per acre) followed by treatment D, A and B. Green manuring with Sunhemp gave the lowest yield of wheat (10.2 maunds* per acre). However, the experiment proved to be insignificant (ARDA, 1940-41).

Eleven varieties (G18, G39, G71, G85, G86, G87, G92, P12, P125, A.O.68 and C499) were experimented at Central Farm, Gwalior during the year 1940-41. Variety P125 produced maximum grain yield (21.4 maunds*/acre) followed by G18, C499, G86, G71, G87, G92, G39, G85, P12 and A.O.68 (ARDA, 1940-41).

Eight varieties, viz., Pipandi White, Pusa 100, Pbc. 591, Pbc. 518, K 808, Kalabal, 9D and Local were tried at the Harsi Experimental Farm, Bagwai during the year 1940-41. The experiment proved significant with regards to both grain and straw yields. Varieties Pbc. 591, Pusa 100, Pbc. 518 and 9D were statistically equal. Varieties Pbc. 518, 9D, Pipandi White and Local were also statistically equalvariety. Pbc. 591 and Pusa 100 were significantly superior in point of grain yield. Kalabal was the poorest yielder. As regards, straw yield. Kalabal produced maximum straw yield. However, it was at par with Pbc. 591, 9D and Pusa 100. K 808 was the lowest yielder in terms of straw production (ARDA, 1940-41).

Twelve varieties of wheat, both local and imported, were tried at the Central Experimental Farm, Gwalior during the year 1944-45. Out of these, G 5, G 15, G 19, Pb 8A, C. 228 and Pipandi White were found promising (ARDA, 1944-45).

An experiment, to ascertain which seed rate gave the best yield under local conditions of Harsi area, was conducted at the Harsi Experimental Farm, Bagwai during the year 1944-45. Seed rates tried were 30, 40, 50, 60 and 70 seers* per acre. The results indicated that 50 seers* seed rate gave the highest yield. The yields were found to be increasing with the increase in seed rate up to a limit of 60 seers*; beyond which the yield was reduced (ARDA, 1944-45).

An experiment, to find out most suitable variety of Wheat for giving the highest yield under dry rainfed conditions, was conducted at the Bhilsa Farm during the year 1944-45. Six varieties were tried in the experiment. Variety Hours recorded the highest yield of 9 maunds* 33 seers* per acre of grain. Then in order were Local Pissi, Vijay, Bansi (Powarkheda), Jay and lastly G.D. 11, each recorded 9maunds* 26 seers*, 8 maunds* 22 seers*, 8 maunds* 17 seers*, 7 maunds* 36 seers* and 7 maunds* 18 seers* per acre, respectively. There was great amount of attack of rust in G.D. 11; while other varieties were slightly affected. An experiment, to find out which seed rate suits the Bhilsa locality best, was conducted at the Bhilsa Farm during the year 1944-45. There were four seed rates (25, 30, 35 and 40

seers* per acre) in the trial. The experiment was non-significant. However, seed rate 30 seers* per acre gave the highest yield of 8 maunds* 3 seers* of grain per acre. The remaining treatment gave almost equal yield with the range of one seer higher or lower yield (ARDA, 1944-45).

Fig. 8. The threshing of wheat near Bhopal (M.P.). Seven bullocks are tied with a rope to a wooden post (methi). They walk around it for hours and throughout the grain

Fig.9. The winnowing of wheat in Madhya Pradesh

Variety G.D. 11 of wheat was grown continuously every year, since last 15 years from 1929-30; to see the effect of continuous cropping of wheat, year after year. It was generally observed that in alternate years there was some slight decrease in the yield of wheat per acre from the same field (ARDA, 1944-45).

Til (Sesame)

About 22 selections from local variety together with some Akola and Poona varieties were tried in year 1926-27 at the Central Experimental Farm, Gwalior. The Jaura variety yielded 120 lbs per acre and topped all other Gwalior selections (ARDA, 1926-27).

About 30 selections both local and exotic were tested in two replicate series having four lines of each. Selections of plants bearing larger number of pods were made and plants bearing six and eight seeded pods were isolated from black and white Akola varieties. Selected white local gave the highest yield of 384 lbs per acre. Amongst others, Jaura, G-11, G-12 and G-17 were promising (ARDA, 1927-28).

In all 16 selections of which 11 were Gwalior selections, 4 were from local villages of the State and one from Akola, were experimented at the Central Experimental Farm, Gwalior, during the year 1930-31. Out of these, 9 selections namely G-4, G-7, G-11, G-12, G-8, G-17, Black Akola, Jaora

and white local proved promising by giving higher yield as compared to other selections(ARDA, 1930-31).

In all 9 varieties (G-4, G-7, G-8, G-11, G-12, G-17, Jaora, White Local and Black Local) were tried at the Central Experimental Farm, Gwalior, which were selected as high yielding selections from results of5 yearsor row tests. Of these varieties, G-4, G-7, G-8 and Jaora proved superior over other varieties (ARDA, 1931-32).

Six varieties (G 7, G 12, G 13, G 24, S 7 and Local) of Tilli were tested at the Central Experimental Farm, Gwalior during the year 1937-38. The results indicated that variety S 7 gave maximum grain yield followed by G 13, G 24, G 7, G 12 and Local. From this it was concluded that variety S7 was superior to all the varieties from the point of grain yield (ARDA, 1937-38).

Nine varieties (G 4, G 7, G 8, G 12, G 13, G 17, G 24, P.S. 7 and Local) varieties of Tilli were tested at the Central Experimental Farm, Gwalior during the year 1938-39. Out of these; P.S. 7 produced maximum grain yield (2.5 maunds* per acre) followed by Local (2.1 lbs per acre) G 7, G 8 and G 12. The minimum grain yield was produced by G 13 (1.2 maunds* per acre) and G 24 (1.2 maunds* per acre) (ARDA, 1938-39).

Eight varieties (G 4, G 7, G 8, G 12, G 13, G 17, G 24 and Pusa 7) of Tilli were tried at the Central Experimental Farm, Gwalior during the year 1939-40. Variety Pusa 7 produced maximum grain yield followed by G 13, G 7, G 4, G 17, G 12, G 24 and G 8 (ARDA, 1939-40).

Ten different strains including local mixtures from the districts were tried for three years at the Central Experimental Farm, Gwalior. Average performance of three years revealed that local mixtures from Ghatigaon, Jora and Sheopur had outstanding yields. But since these were mixtures of Black and White Tilli, it could not be included in the trial without being purified. Hence the outstanding mixtures were grown in single plots and promising selections were made. The strains T. 8, W. 147, T. 1, Black Jamshabad, T. 3 and P.S. 7 were found to be promising (ARDA, 1944-45).

The objective of the experiment conducted at the Central Experiment Farm, Gwalior during 1937 and 1942 was to classify the various varieties of sesame (Tilli), groundnut and linseed on the basis of oil content. For this experiment 28 varieties of sesame, 25 varieties of groundnut and 13 varieties of linseed were analysed year after year for a period of five years. The following are the five varieties of Sesame, Groundnut and Linseed (Table 4) in the order of merit on the basis of their average oil content only.

Table 4: Oil content of five varieties of Sesame, Groundnut and Linseed

Sesame (Til)

S.No.	*Name of Variety*	*Average oil content (%)*
1	T.8	53.6
2	T.6	53.4
3	Ghatigaon local	51.9
4	Ianiasabad Black	50.0
5	T.3	49.8

Groundnut

S.No.	*Name of Variety*	*Average oil content (%)*
1	D.3	47.2
2	Local Jora	47.0
3	A.2 and Local Chachora	46.1
4	C.P. 10	45.6
5	B.1	45.2

Linseed

S.No.	*Name of Variety*	*Average oil content(%)*
1	C.F. White	40.1
2	E.B. 3 brown	39.6
3	Pusa Type 124	39.6
4	Dhar White	37.4
5	Pink Flower 73	37.4

(ARL, 1916-52)

Tobacco

Six varieties of tobacco namely Adcock, P.H. 142, P.T. 28, C.F. Selection, G 6 and Badnagar (Control) were experimented at the Central Experimental Farm, Ujjain during the year 1939-40. The experiment was significant. Varieties P.T. 28 (74.32 maunds* per acre), P.H. 142 (68.0 maunds* per acre) and Adcock (62.52 maunds* per acre) were statistically at par in respect of yield of green leaves. Similarly, varieties C.F. Selection

47.91 maunds* per acre), G 6 (41.68 maunds* per acre), Badnagar (32.76 maunds* per acre) were also statistically equal (ARDA, 1939-40).

Green Manuring

Prior to introduction green manuring, it was considered to carry experiments on green manuring. The experiments on green manuring were initiated in 1919 and completed in 1923. The objectives of the experiments conducted were:

i. To determine the quality of organic matter which was rendered available from green manuring per unit area of land under Gwalior conditions,

ii. To observe the effect of green manuring on the succeeding crop and

iii. To compare the result of green manuring as done by the "Indian Method" versus that by the "Chinese Method"

In the Indian Method, the green crop was directly ploughed into land, whereas in the Chinese Method, the green crop was cut, staked and covered over with earth for its rapid decomposition, Sunhemp was selected as a green manuring crop. As a result of these experiments carried out for a period of five years, it was found out that the green crop weighted 20604 lbs.(of green weight), equivalent to 5930 lbs. of air-dry weight per acre. It was also found that the Indian Method of direct incorporation of the green manuring helped in the soil decompositionwas superior to the Chinese Method of using the same after delayed decomposition (ARDA, 1919-23).

Mixed Sowing Vs Pure Sowing

The experiment was conducted at the Central Experimental Farm, Ujjain to find out whether mixed sowing or pure sowing was more profitable under local conditions. The following treatments were applied:

(i) Wheat (G.D. 11)
(ii) Gram (C.F. Yellow)
(iii) Linseed (White)
(iv) Wheat and Gram
(v) Wheat and Linseed
(vi) Gram and Linseed

The experiment proved significant in respect of net profit in terms of rupees per acre. It was significant to note that the sowing of wheat either singly or mixed with linseed or gram gave more money (ARDA, 1940-41).

The above experiment was also conducted during the year 1944-45 at the Central Experimental Farm, Ujjain. The results indicated that Wheat and Wheat + Gram sown singly and mixed were more profitable economically and were statistically equal. Gram alone, and Wheat + Linseed were

statistically equal and second best economically. Gram + Linseed wassuperior to sowing Linseed alone (ARDA, 1944-45).

Kans Eradication

During the year 1944-45, 'Kans Eradication' by growing paddy after removal of Kans by an implement known as Gahua (Tooth Pegged Patella) was tried in small area as a experimental measure at the Harsi Experimental Farm, Bagwai. The results were quite encouraging (ARDA, 1944-45).

Nutritive Values of Grasses

The objectives of the experiments conducted were to study the nutritive values of grasses grown in Gwalior and to see their suitability for feeding of livestock from the nutritional point of view. The experiments were initiated in 1944. While considering a particular feed for a particular animal, itwas realised that for purpose of feeding, the nutritive ratio was varied in harmony with the purpose in view. A narrow ratio favoured the development of muscular tissue, while a wide one prompted the deposition of fat and the development of heat. The principles which should, therefore, be borne in mind when making mixed ratios for livestock, the work animals should receive a comparatively narrow, while beeves a wide ratio in their food. The milk cows should, however, fed a comparatively high nitrogenous ratios since protection is essential to production of milk. *Echinicloa colona* grass, Giant-star grass and Napier grass had narrow, medium and wide nutritive ratios, respectively(ARL, 1916-52).

Recommended varieties for Gwalior Division

Over 80% of the area cropped in the Gwalior Division comes under jowar, wheat, gram, til, barley, bajra and sugarcane. Varietal trials for these crops were conducted at the Central Experimental Farm, Gwalior. As a result of experiments conducted, following varieties (Table 5)were found suitable for Gwalior Division.

Table 5: Recommended varieties of differenct crops for Gwalior division

S.No.	Crop	Variety	Advantages overlocal varieties
1	Jowar	Sheopur	Higher yield.
2	Wheat	BandaSharbati, Pipandi White, I.K. & G.V. 4, P-4 & P-12	Immunity from rust.

3	Gram	Pusa 17	Higher yield, better uniform colour, freedom from injury due to frost.
		G-16	Higher yield.
4	Til	White	Uniformity in colour.
5	Sugarcane	Co. 205	Higher tonnage and immunity to attacks of wild pigs and other animals.
6	Arhar	Aligarh 70	Higher yield and uniformity of colour.
		Early	Earliness and freedom from frost.
7	Groundnuts	Spanish peanuts	Early maturity and high yield at low cost.

(ARDA, 1931-32)

Recommended varieties for Malwa Division

Varietal trials for different crops suitable for Malwa Division were conducted at the Central Experimental Farm, Ujjain. As a results of these experiments, following varieties of most common crops have been found suitable for Malwa Division (Table 6 & 7).

Table 6: Recommended varieties of different crops for Malwa division

S.No.	Crop	Variety	Advantages of the recommended varieties
1	Cotton	Malwi	High yielding
		Cambodia	High yielding, superior lint, responsive to manuring and irrigation.
2	Jowar	Yellow Bundhel	High yielding.
		W. Bundhel	High yielding.
3	Groundnut	S. Japan	Early, less expensive, dryland crop.
4	Arhar	Early	Surety of crop.
5	Urd	Bhadodia	Suitable for double cropping.
6	Turmeric	Poona	A new introduction of an intensive crop.

7	Wheat	Ekdania	Superior quality grain.
		G.D. 11	Superior quality grain.
8	Gram	C.F. Yellow	Superior quality grain.
		Malida	Superior quality high yielding.
		Kabuli	Suitable for irrigation land.
9	Linseed	White	More profitable.
10	Peas	Khaperkheda	A new introduction of an intensive crop.
11	Sugarcane	Ponda	Higher tonnage of cane.
		S-48	Higher tonnage of cane.

(ARDA, 1931-32)

Table 7: Name of crops and their varieties found beneficial with their advantages at the Central Farm, Ujjain

S.No.	Name of crop	Name of variety recommended	Benefi cial	Variety in vogue to be replaced	Advantages of the recommende d variety.
1	Cotton	Malwi	Yes	Mixture	High yielder
		G. 16	Yes	Mixture	High yielder
		Cambodia	Yes	Mixture	High yielder superior lint
2	Jowar	Yellow Bundhel	Yes	Amla, Titawadi Ratad	High yielder
		White Bundhel	Yes	Amla, Titawadi Ratad	High yielder
3	Arhar	Barley	Yes	Late	Surety of harvest
4	Groundnut	Small Japan	Yes	Local	Earliness
5	Turmeric	Poona	Yes		New introduction
6	Sugarcane	Pounda	Yes	Dhol,	High yielder

				Bansha	
7	Wheat	Gwalior Durum No. 11	Yes	Jalalia, Ekdania	Superior grade
8	Gram	C.F. Yellow	Yes	Mixture	Superior grade
		Malida	Yes	Mixture	Superior grade
9	Linseed	White	Yes	Brown	Superior grade
10	Pea	Khaparkheda	Yes	Batala	Superior High yielder

(ARDA, 1934-35)

(C) Chemical Section

This section conducted the following work:

1.Analysis of soils to determine their suitability to certain crops.

2.Testing different crops such as fodders for good value; sugarcanes for sugar percentage; oil seed for oil contents, etc.

3.Chemical test of cane juice during the process of Gur-making.

4.Testing samples received from Mining, Forest, Medical and Commerce Departments.

For a proper appreciation of the research work to the credit of the Chemical Section of the Agri. Research Laboratories, it must be realised that this Laboratory being the only Chemical Laboratory of its kind in Gwalior State, it was in a way acting as the only clearing house for all sort of analytical work for the whole of Gwalior State since 1930. When as a retrenchment measure the Scindia Chemical Laboratory were amalgamated and the number of Chemists which was four before amalgamation was reduced to two only. The scope of work of the former Agricultural Laboratory after amalgamation was therefore much widened, so as to include work on industrial and other samples as well; a legacy from the defunct Scindia Chemical Laboratories.

As such, besides the agricultural work proper, the Chemical Section had to deal with analytical work connected with samples received from the various other departments of Gwalior Government; as also medico-legal samples from the Medical Department. The samples under the medico-legal head alone averaged to about 120 in a year and this alone was more than enough for one Chemist to deal with. In 1931, as a measure of further retrenchment, the post of Asstt.Chemist was abolished. Thus, during the

period between 1931-1936, only one Chemist was functioning in the Chemical Section and it was only in 1936, that the post of an Asstt. Chemist was again sanctioned.

The analytical work of the section may thus be divided into the following three heads:

(1) **Agricultural samples**: Agricultural work such as the analysis of soils, manures, sugarcane juices, oil contents in oil seeds and water etc.

(2) **Medico-legal samples**: Medico-legal work, i.e., the examination of stomach contents, visceras, food-stuff, etc., for the detection of poison and also identification of Coccaine and Charas.

(3) **Miscellaneous samples**: Work for other State Departmets, such as Mining, Customs, Excise, Forest, Judicial, Municipalities, Store purchase and Water-Works.

A rough idea of the volume of work done by the Chemical Section can be judged from the statement given below which gives the number of samples dealt with, under the various heads during 15 years only (Table 8). During this period a total of 3,874 samples were dealt with. Samples dealt with every year thus average to about 258.

Table 8: Statement showing the number of samples dealt with during 15 years

Year	**SAMPLES**			
(July to June)	**Agricultural**	**Medico-legal**	**Miscellaneous**	**Total**
1932-33	103	15*	5	123
1933-34	116	-	30	146
1934-35	123	51**	0	204
1935-36	160	67	51	278
1936-37	171	59	18	248
1937-38	309	70	56	435
1938-39	367	68	100	435
1939-40	329	154	115	598
1940-41	277	121	227	625
1941-42	218	119	154	491
1942-43	245	143	36	424
1943-44	132	119	58	309

1944-45	44	131	55	230
1945-46	77	107	40	224
1946-47	285	117	18	420
Total	1901	1355	618	3874

***** Medico-legal work which till now was being done in the laboratory was stopped from February, 1933, transferred to Medical Department.

**Medico-legal work was again taken up by the laboratory since December 1934.

The drop in the number of samples under the miscellaneous head from the year 1942-43 was due to the innovation of the practice of charging

analytical fees for samples from other departments except, the Medico-legal, introduced in the year, vide notification in Gwalior Govt. Gazette dated Nov.7, 1942. This was done especially to restrict the number of samples sent by the departments indiscriminately owing to the reason that no fees were charged for them, so as to enable the section to devote more of its time to agricultural research (ARL, 1916-1952).

Fifty three representative soil samples were collected from the Gwalior, Shivpuri, Ujjain and Mandsaur areas of the State. Parent rocks were also gathered simultaneously. Full descriptive notes of the soils were taken. The soils were sampled according to the official standard method, and the samples were divided into 4 parts.

Set 1 was shipped to Prof. Charles F. Shaw of the University of California, who in collaboration with Dr. Lipman of the United States Bureau of soils, was to work on Gwalior soils for mechanical analysis, moisture, equivalent etc.

Set 2 was shipped to Dr. Pendleton who was to study the Gwalior soils in the Soil Technology section of the University of the Philippine Islands.

Set 3 was sent to Dr. Harrison, Imperial Agricultural Chemist; Pusa, for mineralogical examination and percolation tests.

Set 4 remained at Gwalior for such studies as were not under taken by the co-operating parties.

The soil map of the State was prepared and sent to the Photo-Zince Company of Calcutta for print (ARDA, 1923-24).

During the year 1933-34, tests were done to give a better idea about the ripening time, purity and inversion of juice of different and most promisity varieties of sugarcane. Co. 285 maintained its reputation for high sucrose

content and purity of juice. Other varieties were Co. 270, Co. 310, Co. 313, and Co. 301 (ARDA, 1933-34).

Most of the sugarcane juice samples received were in connection with the varietal and manurial tests of sugarcane that were carried on by the crop Botanist, Gwalior. In Gur samples the problem was to find out the chemical difference in Gur made before and after frost that occurred during the winter of 1934-35. Gur made by the same cultivators and from the same varieties of canes turned out to be much inferior after the frost had affected the canes standing in the fields. The Gur made after the frost was softer and inferior in other respects, as the appearance of grain, etc. It was found that a portion of the sucrose was converted into reducing sugar by the effects of frost (Table 9)

Table 9: Effect of frost on Sugarcane crop and quality of Gur

S. No.	Sample	Sucrose %	Reducing Sugars
1	Gur from cane before frost	63.40	10.92
2	Gur from cane after frost	56.20	16.77

The cause of softness in Gur after frost, therefore, was the decrease in sucrose and increase in reducing sugars.

Some of the samples of Gur received specially from Pichhore, Gird were found to be soft because of the presence of large amount of salts which probably were derived from the soil (ARDA, 1934-35).

Most of the sugarcane juice samples received were in connection with varietal and manurial experiments of sugarcane were carried on at the Experimental Farm, Gwalior. Sugarcane varieties Co. 270, Co. 285 and Co. 313 had the highest sucrose content and the purity of juice (ARDA, 1935-36).

During the year 1936-37, few trials on sugarcane were conducted to make cream jaggery with the help of activated carbon from paddy husk. This activated carbon was obtained from the Imperial Agricultural Institute, New Delhi. The jaggery obtained was of good white colour and nice appearance but time taken by the filtration was a great drawback to its extended use by the cultivators of ordinary means (ARDA, 1937-38).

Mr. K.N. Pawar, Chief Chemist, under the instructions of Mr. N.M. Deshmukh, Director of Agriculture, Gwalior Government, visited the Imperial Agricultural Research Institute at New Delhi during the year 1944-45 and discussed with the Imperial Chemist Dr. Desai about the five year plan of soil survey of the Gwalior State. Dr. Desai was very much impressed with the contemplated five years programme of work on soil survey of Gwalior State. He said that it will be a great contribution to the All India

Soil Survey Scheme. The subject was also discussed with Messrs Thomson, Satya Narain and Das and very encouraging remarks were received from them. The Cheif Chemist examined the working of the various sections of Laboratory (ARDA, 1944-45).

The main object underlying before this investigation was to study the soils of Gwalior state with a view to see how far the classification of soils recognised by the Department of Revenue, Gwalior Government in the northern as well as southern divisions of Gwalior State fits in with the classification known to science. Side by side with the above, a crop yield survey with enquiry into economics of crop production was included as this information forms a vital part of the soil study.

Gwalior soils fall into four main group viz.

i. Bhangar alluviums,

ii. Fine sandy soils,

iii. Black sparse sandy soils and

iv. Black cotton soils.

It may here be mentioned that following were the five main revenue classification of soil prevalent in the Northern and the Southern Divisions of Gwalior.

i. Northern Division

(a)Mar (b) Padua (c) Dumat (d) Kabar (e) Banked

ii. Southern Division

(a)Kali (b) Dhamni (c) Bhuri (d) Ranladi (e) Kakreli (ARL, 1916-52)

(D) Mycological Section

Mr. G.S. Kulkarni, Retired Mycologist of Bombay Government was appointed as Mycologist of Gwalior Government and he joined his duties on November 28, 1939.

The Mycologist, Mr. G. S. Kulkarni was In-charge of Mycological Section during the year 1940-41. He organised this section with his Assistant Mr. B.G. Nikam. During the year, the following research work was done:

Wheat Smut

The sun ray treatment of subjecting the seed to at temperature of 113^0F was tried on both the farms at Gwalior and Ujjain. The results were encouraging.

Coriander Wilt

Samples of seed collected from local crops as well as outside places, such as Coimbatore, Burma, Nepal, Lyallpur and Dharwar were tried at two places, viz., Kusmoda near Guna and Bijnipura near Binaganj (Pargana Chachoda). The Dharwar and Coimbatore samples were found to be the least susceptible to wilt attack during 1940-41.

Betal Vine Disease

Two common diseases of wilt caused by a species of Phytopthora fungus and mildew were noticed in a few gardens but are of very minor importance.

Sugarcane Smut

This disease occured in the crop at two stages in its growth; in the seedling stage and in the advanced stage when the crop was about to mature. The attack in the seeding stage caused cent per cent loss because such affected seedlings never grow into canes. In order to determine the loss caused by the disease appearing in the advanced stage, trials of crushing affected and healthy canes were undertaken and the loss due to the disease was estimated by comparing the quantity and percentage of purity of juice obtained from both the diseased and healthy canes. The amount of loss thus calculated during the year 1940-41 was found to be nearly 5% only, which was not so alarming as in the seeding stage.

Gram Wilt

This was a common disease observed in many places in state. It was caused by a soil fungus (*Fusarium orthoceras* variety ciceri). In the affected plants the lower leaves turned yellow or red and began to drop. The remaining leaves then began to wither and plants die. The disease was generally observed when the crop was one month old and the number of dying plants reached its maximum when they were two to three months old. The best remedy so far found effective consisted in breeding wilt-resistant plants. With this idea in view, individual plants were selected from plots at the Central Farm, Ujjain.

Potato Disease

Two diseases; one the Virus disease and the other, rottening of tubers in store, were important. The Virus diseased plants had their leaves reduced in size and crumpled. The space between veins turned yellow. The plants remained stunted and produced tubers small in size and few in number. The disease was carried by planting diseased tubers. The preventive measure consists in preserving tubers of healthy plants for seed (ARDA, 1940-41).

Mr. G.S. Kulkarni held the charge of the section throughout the year 1944-45. Mr. B. G. Nikam worked as his assistant. The following are some of the important plant diseases dealt with during the year.

Wheat Smut

With a view to find out smut resistant wheat varieties; 30 plant progenies were sown in single lines. None showed any resistance as all were affected by smut. Another batch of 30 plants were infected with smut spores and grains from infected heads were collected separately for further testing in the next season.

Jowar Smut

The propaganda against this smut was carried on. The number of sulphur packets sold was 3114. Each packet of sulphur was enough to treat seed for 3 bighas*. The treatment saved the loss of Rs. 3 per bigha*. The total gain accrued from treatment amounted to Rs. 28,026. Thus the treatment saved the cultivators from a loss of Rs. 28,026 as against Rs. 20,358 in previous year.

Wheat Rust

This was the third and the last year of Wheat Rust Research. Sixteen varieties were sown at Gwalior Farm and 12 at Ujjain Farm. Of these only two varieties viz. Manawar white and Manawar Red seed were promising. All the rest 26 were susceptible. These two varieties along with other 12 varieties from Bombay, C.P., Indore, and Imperial Agricultural Research Institute formed the basis material tested in the field at the Bhilsa Farm.

Potato Cold Storage

112 maunds* of seed was stored in racks, bags and baskets. The rack method of storing Potato tubers was found most economical. The racks can hold more potatoes per cubic foot for storage. The temperature maintained was 35^{o} F.

Potato Crop Improvement

The experiment was started to build up a nucleus good seed true to type and free from disease. Phulua variety was grown on Gwalior Farm on 1 acre plot.

(E) Entomological Section

Mr. C.B.L. Bhargava was appointed as Entomologist of Gwalior Government and he joined his duties on February29, 1940.

The Entomologist, Mr. C.B.L. Bhargava organised the section with his assistant Mr. Harbans Lal during the year 1940-41. The work done during the year is being mentioned below:

The work done by the Entomologist falls under two broad heads:

(1) General survey and study of important pests and their control measures.

(2) Investigations in connection with sugarcane pests and potato moths.

1. The following are some of the important pests for which reports were received and control measure were adopted :

Pyrilla

This was the most important pest of sugarcane. It was found to be serious in canal irrigated tracts. In July and August its number was very small but it began to multiply from September and reached its maximum in October. The crop was then sprayed with Crude oil Emulsion and Sanitary fluid; whereby 80% of the eggs and nymphs were considered to have been killed. The eggs laid by the adults that survived were, later on collected and destroyed also the surviving adults were collected by hand nets. Thus the attack was controlled and damage was minimised.

Sugarcane Borer

Amongst these borers, Top Shoot borer was more prominent appearing in the later part of the season.

Cut Worms of Wheat

This pest was noticed in an epidemic form at Bansgarh. Poisonous bait was tried in an acre plot and its efficacy was demonstrated.

Jowar Stem Borer

Most common pest of Jowar was reported from many Paraganas. It was also noticed at the Central Farm where the dead hearts were regularly removed and burnt.

Stored Wheat Weevil

The Co-operative Bank at Dabra had stored wheat seed which was heavily attacked by weevils. The seed was cleaned and exposed to sun. Before refilling the Godowns were also got cleaned and fumigated with sulphur fumes and their side walls painted with coaltar. Thereafter the seed remained in good condition.

Citrus Whitefly

Some affected leaves sent by the Crop Botanist, Malwa, were on examination, found infested with this pest. Spraying with tobacco decoction and soap solution was advised.

Lemon Butterfly

This was the most common pest damaging the young plants in its caterpillar stage. Hand-picking was found to be a very effective remedy.

Guava Beetle

Leaves of the guava plants in the nursery of the Central Farm, Gwalior used to be attacked and eaten away by some beetles and acridids at night. All the plants were sprayed with Lead Chromate solution after no more damage was done.

Singhara Beetle (*Calerucella singhara*)

This beetle was found attacking the leaves of Singhara crop, whereby the plant could not bear fruit and were observed to dry up. Kerosene oil treatment did not succeed. Hand picking of adults and grubs was found more effective.

Sweet Potato Weevil

It was a common pest of sweet potato. The life history of the pest was explained and the right way of disposing of the affected tubers was demonstrated to the cultivators.

Investigation

(i) Sugarcane was one of the most important crops and considerable damage was reported every year by insects pests. A study of different borers and the extent of damage done to the crop; side by side with the study of different parasites of Borers and Pyrilla was taken up.

(ii) A few larvae of the potato moth were collected and kept for observation. It was observed that the moths mate early in the morning which last for about 45 minutes. After four days the first batch of eggs are laid. The total number of eggs laid by a pair was 48 and the adults lived for 13-15 days. The eggs so laid did not hatch and hence further study had to be postponed.

On examining the potatoes stored by the Mycologist in a refrigerator at 35^0 F. a larva of potato moth was found boring into one of the tubers. This potato was put separately. After a few days it (larva) was found spinning a whitish cocoon and resting in it. After four days it pupated and remained in that condition for 27 days. The adult moths that emerged at room temperature were kept in refrigerator where a pair was found laying as many as 64 eggs. Thus it was found that a larva and moth can live and survive at 35^0 F and the adults live up to 32 days. As the eggs again failed to hatch at that temperature further study could not be pursued(ARDA, 1944-45).

Dr. Ram Rakshpal remained In-charge of the Entomological Section during the year 1944-45 and Mr. Harbans Lal continued as Assistant. The work done during the year is being summarised as below:-

Occurrence of crop pests and control measures suggested

Jowar: A number of reports were received regarding the attack of hoppers on the germinating Jowar seedlings. Baiting and trenching were advocated for control measures.

Citrus White Fly: This was infesting the garden belonging to Mangi Lal Seth of Piploda village in Shajapur District. It was controlled by spraying with an insecticide prepared on the spot. The insecticide was prepared with 4 chhatank of sodium carbonate, 1 ½ seers* of Rosin and 4 ½ gallons of water. This was sprayed on 29 plants with the result that the owner got a bumper crop of fruits. In the past years he used to get nothing, while in the year under report he sold fruits worth Rs. 5,000.

Seventeen samples of crop pests received from the various staff of the Department were identified and control measures were suggested. The study of the incidence and effect of borers on the sugarcane crop sown in different months of the year was now concluded.

The observations recorded showed that there was a very little difference in the damage caused by the borers on the sugarcane crop sown in different months of the year was concluded.

The observation recorded showed that there was a very little difference in the damage caused by the borers to the sugarcane crop sown in January and February. The following borers attacked the crop at different times:

A. *Scirpophaga nivella:*This borer was most active from October to January.

B. *Emalocera depresella:*July was the month when this borer was found to the maximum and was more active, irrespective of sowing dates. After July the attack was decreased.

C. *Argyria sticticraspis:*The period of maximum attack for borer was very irregular.

D. *Seasamia species:*The period of maximum attack for this borer varied from July to October, later on it was on decrease.

E. *Dead hearts:*Maximum number of Dead Hearts were found during the months of October and November.

Stored grain pests

The experiment on use of mercury to control the stored grain pests on a commercial basis was taken up.

Research

The research on the following parasites was taken up along with the usual routine work of the Section.

(1) *Sphaerophoria scutellaris* Fab(Syrphid-Fly)*:*was a predator on mustard aphid. The life history from the laying of eggs to moth stage was studied.

(2) *Lecopis griseola*Fab(A. Fly)*:*This was another predator on mustard Aphid. The life history from egg to moth stage was studied.

(3) *Rhopalosiphum pseudobrassicae* (Mustard Aphid)*:*- This was a serious pest of mustard and other cruciferous plants which was controlled by spraying fish oil or sin soap. The study of the life history was carried out.

(4) *Control of Citrus fruit sucking moth:* Since many years reports were received regarding damage done to citrus fruits, other than lemons, by this pest. Control measures adopted previously did not prove helpful. Hence a new control measure was adopted in which the time of fruiting was to be controlled. It was suggested that the January and February crops only be taken; while October, November crops should be with held. By the elimination of the fruiting period coinciding with the period, when sucking moths was very active, the damage to the crop was avoided.

(5) *Bagrada picta:* This was one of the most serious pests of a number of cruciferus plants. Lot of damage was caused to the cabbage and cauliflower during the year by this pest. To find out suitable control measures the biology of the pest was studied.

(6) *Stomxys bengalensis* picard*:*It was parasite of Bagrada picta. The life history of the parasite was studied.

(F) Agricultural Engineering Section

Introduction of Bullock Power Implements

Different kinds of ploughs, harrows and cultivators were tried on the Central Experimental Farms. Of these, Sabul, Chattanooga and Scindia ploughs were very serviceable, whenever these were exhibited at the district Melas or were demonstrated at the Central Experimental Farms. Doffans and Tiffans were steadily replaced by the country Nai (Plough) for the purpose of sowing crops such as wheat, gram, jowar and cotton.

The Agricultural Engineering Section tried to design a new plough called Scindia plough and got manufactured at the Gwalior Engineering Works. It was of simple mechanism, easy to handle, reasonable in price and

yet it was very efficient when compared to many iron ploughs of its kind, now in market.

The use of an iron plough coupled with Doffan proved to be of immense benefit to many cultivators all over the State and in the wheat districts in particular, gave them an additional net profit of Rs. 12-0-0 per bigha* as compared to profits realised by the company methods of ploughing and sowing.

In order to meet the requirements of sugarcane growing districts the Agricultural Engineering Department owened a sugarcane crushing mill more or less of the type of Nahan Mill. These mills, though equally efficient, werecomparatively cheaper in price. Therefore,was in great demand for them in the sugarcane growing areas of the Gwalior State(Pandya, 1931).

Scindia Plough

Agricultural Engineer Mr. Don W. Griffin produced a plough (named as Scindia plough) in all respects adapted to the small Indian Cultivator. This plough had the following characteristics:

(a) It was cheap, at pre-war prices it could be turned out at about Rs. 6.

(b) It turned a furrow six inches wide and up to six inches deep.

(c) Its draft was such that an average pair of village oxen can pull it without distress.

(d) Its construction was such that the ordinary cultivator can adjust it, as easily as his wooden plough.

(e) It had a steel bar point which could be turned over, when dull on one side and thus a continuously sharp point was obtained.

(f) It had only one handle and the cultivation was as near oxen, as it was with his ordinary plough.

(g) It could easily be repaired by the village blacksmith.

(h) It was enduring. It would last the ordinary farmer for the life – time.

(i) It enabled the farmer to work additionally. While with the ordinary country plough he would have to sit helpless during the activity.

(j) It did more and better work with one ploughing, than the country plough,did in six ploughings.

(k) All stubble and manure was turned in, where it would do the most good. (ARDA, 1917-18.)

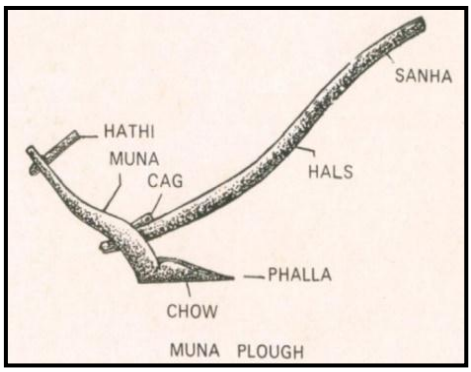


Fig. 10.Desi plough

Fig. 11.Ploughing with desi plough

Tractor versus Bullock-ploughing

In order to compare the cost of ploughing by tractor and bullocks, the tractor was run on a measured area of 5 acres. Also an average of several days work done by three plough drawn by bullocks was taken as the basis of computing the cost of bullocks labour ploughing with Sabul plough; which was heavy with iron plough requiring two pairs of bullocks. The results of the test are given as below (Table 10 & 11).

Table 10: Cost of ploughing 5 acres with Tractor

S. No.	Item	Amount	Cost			Cost per acre			Remarks
			Rs.	a.	p.	Rs.	a.	p.	
1.	Kerosene	26 gal.	26	0	0	5	3	2	The tractor could plough 1.67 acres per day of 12 hours.
2.	Mobil oil	1 gal.	5	4	0	1	0	9	
3.	Grease and Petrol	-	0	10	0	0	2	0	
4.	Driver	3 days	4	0	0	0	12	9	
5.	Depreciation	10%	5	1	0	1	0	11	
6.	Interest	10%	5	1	0	1	0	11	
					Total	9	4	6	

Table 11: Cost of ploughing 1 acre with Sabul plough

(Average of several days work)

S. No.	Item	Amount	Cost			Remarks
			Rs.	a.	p.	
1.	Bullocks	2 pairs	1	8	0	Actual feeding expenses came to annas 12/6 per pair per day. One Sabul Plough with 2 pairs bullocks, 2 men could plough 1 acre a day.
2.	Men	2	0	13	0	
3.	Interest	10%	0	2	8	
4.	Depreciation	10%	0	2	8	
5.	Rope	-	0	1	0	
		Total	2	11	0	

The test showed conclusively the economy of bullock labour. What then was the use of a tractor? In many places it was becoming increasingly difficult for Zamindars and others operating large areas of land to get men enough to drive their bullocks. They consequently had to work their land shorthanded, which means delay in all the farm operations and resulting in lower yield. For these men it would undoubtedly be profitable to buy a tractor so that their heavy operations such as ploughing and bakharing could be done in time. A large tractor with one driver and a helper would do as such work as several pairs of bullocks, and it would certainly be to the advantage of the Zamindar to get his work done promptly (ARDA, 1921-22).

Stone-Roller versus Bullocks Threshing

Experiments were carried on for comparing the threshing of Jowar by a stone-roller. The results obtained showed the superiority of the latter method over the former. The cost of threshing by bullocks of 1,000 lbs. of Jowar head came to Rs. 4-11-0 while cost of threshing the same quantity of Jowar head by a stone–roller was Rs. 0-15-9; *i.e.*, use of a stone-roller for threshing Jowar reduced the cost of threshing it by bullocks as generally practiced by about 77% (ARDA, 1922-23).

Nahan Sultan Mill versus Shivpuri Mill

Compared with the Nahan Sultan Mill, the Shivpuri Mill was found to express about 10% less juice, causing an annual loss of Rs. 25 per acre, for an average Cane crop (ARDA, 1921-22).

Uses of Bakhar versus Modern Harrow

With the spring tooth and the spike harrow about 8-10 bighas* of land was handled with only a single pair of bullocks per day. These harrows were found suitable for producing the desired tilth and keeping the desired mulch over Rabi lands only after the latter had been rendered free of weeds. These modern harrows did not show merit to replace the country bakhar which was capable of performing manifold functions.

	Uses of Bakhar		Uses of Modern Harrow
1	It could be worked for the general purpose of cultivating the fields at any time after the removal of the previous crop.	1	It was lacking in the important aspect of cultivation.
2	It could be worked to destroy weeds that grow luxuriantly in the rainy season.	2	It was lacking in the another important aspect of cultivation.
3	It could be worked to get tilth and mulch on the Rabi lands. In this respect, the working of a bakhar was more costly than that of a modern harrow.	3	The modern harrow was the most economical implement for getting good tilth and mulch on Rabi lands.
4	It could be worked to earth up seed sown by broadcast system.	4	The modern harrow earths up seed up sown by broadcast system very economically.
5	It could be worked to stir up soil after the seed was drilled in.	5	The modern harrow stirs up soil after seeding was done very efficiently and economically.
6	It was so simple in construction and so inexpensive that the most ordinary farmer could afford to buy one.	6	The modern harrow was expensive in cost.
7	The repairs to bakhar could be done by the local carpenter	7	The repair to the modern harrow was dependent on spares available.

(ARDA, 1925-26 & 1926-27)

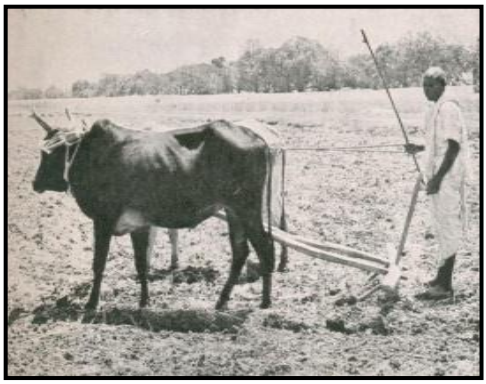


Fig. 12.Bakhar a scraper in common use in the black-cotton-soils areas of Madhya Pradesh

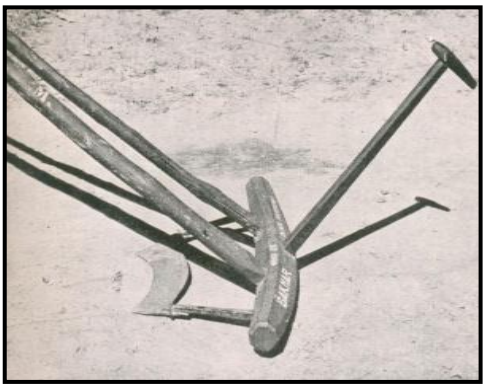


Fig. 13. Closer view of Blade Harrow (Bakhar)

(G) Institute of Plant Industry, Indore

Education and Training

One of the greatest contributions that Institute of Plant Industary, Indore had made to the then existing States was in the training of their nominees in general agriculture or in special processes, such as gur-boiling, tobacco-curing, compost making etc. Training was given free and quarters were provided. The period of training usually varied from four weeks to twelve months. On completion of their training such men were usually employed in State Agricultural Departments for effective improvements in their own areas.

In addition to the students who came to stay at the Institute to receive training, there were a large number of casual visitors to the farm. Parties of students from colleges and other institutions were also conducted round and given demonstrations and explanation of the work in progress.

The Institute had been imparting Post Graduate training in different subjects particularly in Plant-Breeding, Physiology and Statistics and the students had taken degrees of Ph. D and M. Sc. from different universities as follows:

University	Degree	No. of candidates.
Bombay	M. Sc.	12
Nagpur	M. Sc.	2
Punjab	Ph. D.	1

In 1946 a two-year Diploma course was started for imparting agricultural education to the nominees of the States and this continued till June, 1950. Two other educational schemes, *viz.*, the Basic Agricultural Training School for Training the Village Level Workers (VLWs) and the Adivasi Training course were conducted without any financial commitment to the Institute.

Basic Agricultural Training School: The period of this training was one year. The boys were examined underthe prescribed course and the successful trainees had to undergo a further course of practical Agriculture in a village for six months at Antri (Gwalior).

The following officers of the Institute conducted the classes in addition to their own duties at the Institute:

i. Entomologist
ii. Plant Pathologist.
iii. Agronomist
iv. Farm Superintendent
v. Asstt. Farm Supdt. and
vi. Chemical Assistant.

In addition to this staff, the Horticulture and Animal Husbandry Instructors were appointed by the State Government who, in addition to delivering lectures, accompanied the students for practical work in the villages. They were helped in their duties by the four demonstrators also; appointed by the Madhya Bharat Government.

In the Adivasi training class, the students besides undergoing theoretical and practical training at the Institute visited the selected centres of the Community Project areas along with the students of Basic Agriculture Training School in the school van every Saturday. Whereby they get an opportunity to discuss at first hand many agriculture problems with the cultivators. The Farm Superintendent and the Assistant Farm Superintendent took their classes in addition to their own duties.

The general supervisory work of the schools, however, was carried out by the Director of the Institute, who has been vested with drawing and disbursing powers or the budget sanctioned for the schools.

Statistical Education and Training: The statistical Section admitted research students for the M. Sc. degree for Statistics and M. Sc. (Ag.) of Bombay and Nagpur Universities, respectively. Nine students were awarded post graduate degrees of these Universities.

In addition to this about 25 students, deputed by various Governments, were trained at the Institute in planning of trials, their analysis and interpretation of results. Regular lectures on the field and plant breeding techniques and application of statistical methods to the study of quantitative inheritance were held to train the students and the staff members of the Institute.

The section has been given all possible help to the staff members of other sections of the Institute in planning experiments, analysis of data and interpretation of results. It also helped officers of the former Madhya Bharat Government and in charge of various schemes for planning of experiments and other statistical problems.

A comprehensive analysis of about 800 varietal trials on various crops was carried out by the statistical section and the results were written up as a bulletin of the Institute. In addition to this a detailed analysis of varietal trials on cotton crop carried out at Government farms in the former Madhya Pradesh; was carried out and the report of this examination was submitted to the Indian Central Cotton Committee for recommendations.

Entomological Teaching: Entomological teaching was an important part of the duties of the Entomologist. Regular theory classes and field practicals were conducted from 1946 onwards. Students taught were the Diploma Class students, Officers of the Development Department, Village Level Workers and short course students.

Pathological Teaching: Teaching has been done by the Plant Pathologists from 1946 onwards. They taught Botany and Plant Pathology to the Diploma Class of Agriculture at the Institute and delivered lectures in Plant Pathology to the Officers of the Development Departments and short course from the same department.

Research Achievements

(a) General

Only improved appliances and operations which have proved of practical benefit to the cultivator are mentioned as follow:

(1)Compost: An outstanding method for augmenting the supply of plant food to the soil is the process of composting. This process was originally worked out at this Institute and consists essentially the breaking down of vegetable matter by controlled fermentation until a valuable manure containing a high proportion of humus is produced. It is the cheapest source of supplying nitrogen to the soil as most of the Indian soils are deficient in nitrogen. This method is advocated for remedy of deficit of nitrogen.

It may truly be said that the pioneer work carried out at this Institute on composting has been of far-reaching importance to agriculture, particularly in tropical countries. No activity of the Institute is so well known as compost making. It was at this Institute that the technique was first worked out and perfected and from the Institute is spread both as a routine practice among agriculture departments, both in India and abroad, and as an object of research among agricultural scientists.

There is no doubt that the manufacture of Indore compost offers an ideal method of increasing the available manure supply, that it has proved successful in practice and is within the reach of every cultivator.

First ever aerobic technique of composting popularly known as Indore compost was developed at Institute of Plant Industry (IPI), now College of Agriculture, Indore by Sir Albert Howard and Yashwant Wad (1931). It was appreciated by Mahatma Gandhi during his visit to IPI, Indore on April 23, 1935 (Fig.14 & 15).

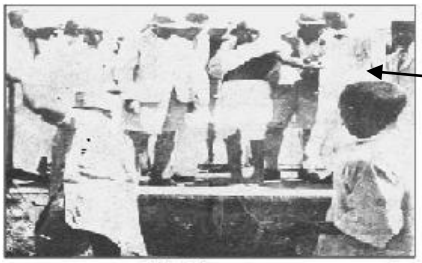


Fig. 14.

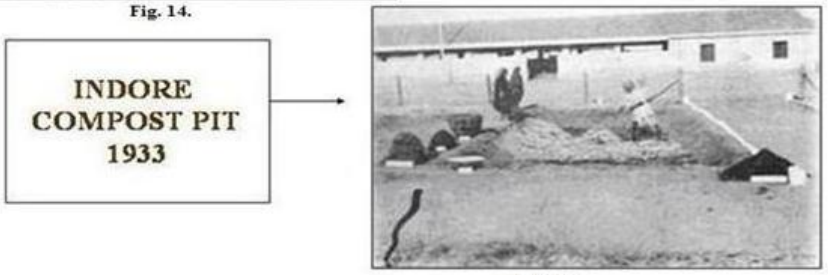


Fig. 15.

There are two methods:

I.Pit composting and

II.Rain water composting

For pit composting the daily farm wastes are dumped into a pit during winter and summer and pit is turned and watering is done every fortnight. The material thus treated becomes a good manure within four months and produces 40 to 50 cart loads from one pair of bullocks against 10 to 12 cart loads produced by the farmer.

In rain water composting the daily farm wastes are arranged on the ground surface during rainy seasons and nothing else is done except giving 3 to 4 turnings during the rainy seasons and the compost is ready within 3 months and produces about 30 cart loads of compost containing about 1% nitrogen.

Use of Fertosan for composting: Two organic compounds Fertosan and Fertosan 1451 claimed to accelerate the decomposition of farm wastes, so as to make the compost ready within 8 to 10 weeks, were used in heaps during summer, winter and rainy seasons of 1954-55. These compounds were found effective during rainy seasons only and Fertosan 1451 proved more effective than fertosan.

Two of the most pressing problems on the black soil of this region, *viz.*, the loss of soil-fertility due to erosion and the prevalence of kans grass, a particularly difficult weed to eradicate have been studied and ameliorative measures suitable for the use of ordinary cultivators have been worked out. The former can be checked by suitable bunds and drainage channels and the latter be easily eradicated by regularly cultivating the land with a blade harrow (Bakhar) at an interval of a week for eight months (from November to June). Small popular pamphlets have been written on both of these processes for distributing them to the cultivators.

(2) Appliances and Implements: Two important implements recommended by the institute are:

i. Kans plough for the eradication of kans, which is very pernicious weed in these areas.

ii. Indore ridger for ridging groundnut and for interculturing operations in kharif crops.

A series of leaflets in simple vernacular have been published, describing the various improvements mentioned above and showing how the cultivator may himself take advantage of them.

(3) Extension work for the State: The Extension Officers of the Institute used to conduct demonstration of improved method of farming in important places situated in the contributing State in Central India and Rajputana. The Farm Superintendent was also a part-time Extension Officer to assist the Extension Officer in carrying out his duties.

Other lines of extension work consisted of the sale and distribution of improved implements, the demonstration of compost making, cane juice boiling by improved furnace, silage making, the eradication of kans and tobacco curing by grass curing method.

Seed Multiplication and Distribution: Seed of improved varieties of kharif and rabi are multiplied and supplied to the Department of Agriculture of Madhya Bharat and the cultivators of four adjoining villages. Cotton seed is supplied to these cultivators on the condition that they would sell the seed cotton to the Institute for ginning at the Institute ginnery for maintaining the purity of strain. The seed is again supplied to the Department for multiplication and the lint sold to the local mills.

Seeds of the following crops are multiplied at this Institute:

Kharif; Cotton: Bhoj [selection from Malvi], Malvi 9, Maljari, 197-3, Indore 1 and Indore 2 among the Americans.

Jowar : Early I.P.I. 3.

Tuar: Type 5, Paddy: Barwani 22, Basmati and Palmar

Groundnut: Ak. 12-24, Mung: U.P.I.

Rabi; Wheat:Malvi Ekdania, N.P. 710, N.P. 718, C. 591

Gram deshi quality such as Green gram, Dhar 2 & Malida.

Linseed T. 11 and T.65.

Peas-Khaperkheda, T. 19 and T. 163.

Miscellaneous: Sugarcane Co. 419, E.K. 28 and Ashy Mauritius.

Stizolobium for fodder purpose.

*Implements:*The Institute was recommending implements to the former States and the then Madhya Bharat Government Agricultural Department after they have proved their suitability and were reasonable in price. Such implements which have been thoroughly tested and have been found suitable were small soil turning ploughs, the Indore ridgers and dauras for intercultivation, levellers and kharif and rabi seed drills, manure turning forks and drag-rakes. Other implements were three roller cane crushers, gur-boiling pans, threshers, chaff-cutters and kans ploughs. All these have proved themselves useful. Most of the implements mentioned above were kept in stock at the Institute under the trading section for supplying to the department and cultivators.

(b) Cotton Breeding and Genetics

The fundamental research in cotton botany at the Institute was mainly directed towards solution of such problems, as would be useful to the Cotton breeder, in general. It was realised that since the various plant characters themselves constituted the cotton plant, knowledge regarding them and their inheritance was essential. Accordingly, experiments were conducted for:

(a) Adding to the existing knowledge of different characters of the cotton plant,

(b) Studying mode of their inheritance,

(c) Collection of information regarding the relationship between different varieties, races and even species,

(d) Standardisation of statistical methods as would enable the selection and testing in cotton breeding more efficient and objective, taxonomy, ecology, statistics, etc. and results achieved are incorporated in 106 publications listed at the end.

The cotton breeding programme envisaged the improvement of cotton crops grown under conditions of wide diversity extending from the arid Bikaner desert in the north to the fertile Nimar (Narbada) zone in south. This work for the different tracks was carried out in collaboration with the local authorities and also through the operation of special schemes and sub-stations established for the purpose in the tracts under the technical guidance of the Institute. The Institute has been hitherto responsible for the evolution of seven new strains of cotton *viz.*, Malvi 9 and Bhoj for Malva *barani* (rainfed) condition, D. 48-154 for Nimar tract, M.U. 4 and Indore 2 for Malwa adhan lands, Indore 1 for Banas basin of Udaipur and Ganganagar for Bikaner Division of Rajasthan.

The work has now been in progress for more than twenty-five years and therefore it would be in order to present a brief consolidated review of all the published and unpublished work carried out in the Botany Section during the period.

(1) Cytology

Bannerjee (1929) studied the chromosome numbers of various varieties of cotton and established that the indigenous varieties belonging either to *Gossypium arboreum* or *Gossypium herbaceum* had thirteen as the haploid chromosome number. The exotic ones belonging either to *Gossypiumhirsutum* or *Gossypium barbadense* had n=26.

Ramiah and Gadkari (1941) studied the cytological behaviour of the heritable sterility of Million Dollar rogue and found that the spore mother cells of different sterile plants were characterised by a number of univalents, a few bivalents and some multivalent. This suggested absence of normal pairing of chromosomes *i.e.* asynapis, as the cause of sterility.

Subsequent cytological work at the station has been confined to the determining of the chromosome numbers of colchicine hybrids.

(2) Genetics

Genetical work carried out at Indore covers a wide field ranging from simple factorial analysis to studies in polygenic inheritance, the details of which are briefed as follows:

(i) Chlorophyll deficiencies: Hutchinson and Bholanath (1938) studied the inheritance of a chlorophyll deficient mutant in Malvi 9 (*C. arboreum race bengalense*) and found it to be controlled by a single recessive gene designated as *Chl-Chl;*the normal being fully dominant.

Subsequently Bholanath found two new chlorophyll deficient mutants in Jarila. These were monogenic in inheritance: one, "light green" in appearance; is fully viable and the normal being completely dominant; and the other "yellow seeding" is lethal in effect and is incompletely recessive, the heterozygote being fully viable and distinguishable from normal by its yellow top. It was found that the genes for these two deficients formed a multiple allele series, the gene locus assorting freely with the other major genes with which it was tested.

Sterility- A case of heritable sterility (both on male and female side) was recorded by Hutchinson and Gadkari (1935) in Million Dollar cotton (*G.arboreum race sinense*) which was found to be controlled by a single recessive gene *Stp-Stp,* fertility being fully dominant. Ramjah and Gadkari (1941) studied one causing asynapsis and was not linked with either L, Y_a, R_2 Loci.

(ii) Crumpling: Bholanath and Govande (1943) found that Rozi cotton of Gujarat carried the complementary gene Cpa which brought about crumpling in Asiatic cottons.

Hutchinson and Ghose (1937) recorded the occurrence of the crinkled gene *Cr* of *barbadense* cottons in the Malwa Uplands cotton which belonged to *G. hirsutum.* Further work by J. B. Hutchinson, has shown that this gene was a member of multiple allelomorph genes at *Cr* locus in new world cotton.

(iii) Hairiness: Ramiah and Paranjape (1944) found a new type of hair *viz.*, stellate in Viramgam lintless, which is unassociated with lintlessness. It should be simple monodenic inheritance, normal being fully dominant, the gene being H_b -h_b. Paranjape (1946) further surveyed the hairiness in all the Indian varieties of cotton and suggested that in *bengalense* and *burmanicum* groups, yellow flower type as a class were more hairy than white flowered ones. His studies showed that the *herbeceum* varieties studied were not more hairy than *arboreums* but the rays of their stellate hair were much longer than the ones found in arboreum.

(iv) Leaf-shape: Hutchinson, Ghose and Bholanath (1939) discovered one more member of the multiple allelomorph series of locus *L* of Asiatic cotton and designated it L^N.It has a deeper cut sinus giving higher index A than the types carrying *L*.

Later Ramiah and Bholanath (1943) described a single inherited gene designated as *S-s* which controlled the entire leaf lobbing, the normal lobed condition being fully dominant over the entire or unlobed condition. It was further discovered that this gene was independent of the leaf shape locus *L* and also assorted freely with $Y_a$and $L_e$loci.

(v) Anthocyanin: Huthchinson and Ghose (1937) reported a new, seventh member of the anthocyanin multiple allelomorph series R^O which was similar to R^L vegetatively and R^o in flower spot and in this respect complentary to R_g.

They also indicated the presence of another spot reducer gene, *Sr-sr* which assorted independently of R_2 locus.

Later Ramiah and Bholanath (1944) described two more anthocyanin types in Asiatic cotton which fitted in the pattern of allelic series described by Silow and Yu. These types were 'weak thumb nail spotless' R_2^{GB} , and 'green spotted' R_2^{HO}.

Subsequently further studies by Bholanath showed that the duplicate R_3^{GO}(gold perat/spotless), ex *G. anamalum* reported previously by Silow, in its cross with r_2^{oo}, the basic green/spotless member of R_2 series, has led to the isolation of the $r_2^{oo} R_3^{GO}$ genotype, which is of the phenotype green/ gold petal/ spotless, suggesting parallelism in gene architecture of the R_2 and R_3loci.

(vi) Corolla colour: Bholanath (1942) studyied the genetics of a pale petal, mutant in the Chinese variety, N 14; concluded that a new complementary gene Y_b-$y_b$was invoked. It was further noted that this gene locus *viz.* Y_b-$y_b$was not linked with either R_2or Y_a.

(vii) Petalody: Hutchison and Ghose (1937) found that the dominance in the petalody gene *Pdy-pdy* was incomplete and not full as reported earlier by Ramnathan and Sankaran.

S. R. Kaiwar (unpublished) studied the linkage relations of the petalody gene with R_2, *L* and $Y_a$loci and found that each of these loci assorted freely with *Pdy-pdy*.

(viii) Boll character: Ramiah and Bholanath (1944) studied the boll characters and found that so far inheritance of soil size was concerned, bigger size, as noted in Bishnoor (G. *arboreum* race *bengalense*) was dominant in F_1. And the character was controlled by multiple genes. A further study of boll size, seed and ovule numbers in *G. arboretum* showed

that varieties belonging to Forma *indica* had lower numbers of ovules and seeds per lock as compared to *bengalense* varieties. It was also noticed that the bigger boll was associated with narrow leaf.

(ix) Lintlessness: Hutchinson and Gadkari (1937) studied the genetics of seven lintless mutants in *desi* cotton and found that four independent genes *viz.* h_a, h_b, li_a, and li_b were involved. The genes h_a and h_b brought about glabrous plant body as additional pleiotropic effect. Further, any two of these four genes were complementary to one another for lint production. The genes h_a and h_b assorted freely with either *L*,Lc_1, N_e or *Y* locus; he was also not linked with R_2. The Li_c responsible for hairy lintless nature, was reported to be lethal in homozygous condition by the earlier workers was found to have become suddenly viable. It was, however, not related to any of the other four lintless genes and assorted freely with *Y*, N_e and Lc_1 loci but families segregating for leafshape showed strong association between this lintless gene and broad leaf.

Ramiah and Kaiwar (1942) studied the pleiotropic effects of the Punjab Hairy lintless gene $Li_c$and showed that it brought about reduction of plant height, number and length of internodes. It also inhibited fibre development and affected boll size and fertility.

(x) Fuzziness: Bholanath (1948) studying the genetics of seed fuzziness in the American cottons acclimatised in India showed that the fuzz grade intensity in the Indian *hirsutum* was determined not only by the already known single gene difference but also by a number of modifiers which are different for different varieties.

Ramiah and Bholanath (1946) observed that low fuzz grade of the Indian *hirsutums* was associated with lower ginning percentage as well. Bholanath further studied the relationship of fuzz colour with fibre properties in *hirsutum* cottons of Deccan plateau and lower seed weight.

(xi) Wilt resistance: Hutchinson, Gadkari and Ansari (1937) studying similar data of Fahmy on geneties of wilt resistant in Egyptian cottons suggested a multiple factor theory for inheritance of *Fusarium* wilt resistance in cotton.

(xii) Red leaf disease: Red leaf disease usually known as red leaf blight is common amongst American cottons in Malwa. Ramiah and Bholanath (1944) studied occurrence of two types of red leaves in the American cotton of this tract and pointed out that while one was associated with jassid attack, the other was purely mendelian in character, showing monofactorial inheritance with normal green, the dominance of which was incomplete. It was also pointed out that mendalian red leaf did not do any economic lossed and made the crop early. This, however is not the position in case of red leaf caused by jassid, where kapas yield was adversely affected.

(xiii) Jassid resistance: Ramiah, Bholanath and Phadnis (1946) showed that resistance to jassids of various upland families was related to the time of sowing, since it was noted that many resistant families succumbed when sown late. The susceptible progenies, however, suffered in all sowing. By progressive selection on the basis of healthy leaves, resistant progenies were evolved at Indore. It was noted that the production of mean number of bolls per plant in resistant progenies was definitely higher than in susceptible progenies.

(xiv) Lint length, ginning percentage, kapas, yield and node number: Since all these economic characters of cotton are controlled by genes of small effect and therefore their genetic analysis has been hitherto impossible due to difficulty of elimination of environment effect which possibly led to the blending inheritance. Nevertheless efforts were made by Hutchinson, Panse and Govande (1938) to study the interstrain crosses *viz.* Malvi 9, Bani and C 520. They found that a strong heterosis was demonstrated in all of these characters, the F_1differing from the mean of the parents and the F_2 falling between the F_1 differing from the mean of the parents. The direction of heterosis was as expected, towards higher mean values in case of lint length, ginning percentage and kapas yield and towards lower mean value in case of node number. Further, even after adjustment, it was found from the ratio of the F_1 toF_2variances, that the environmental condition remained a very high proportion of total variance.

Ganesan (1942) found that the hybrid vigour in the above crosses was detectable in the seed itself. Studying purely the genetic effect on seed and its parts, he concluded that hybrid vigour manifested itself in seed weight, but not necessarily in the various parts of the seed (the meristematic capital in particular) studied separately. This has been attributed to the effect of competition and probably working of the compound interest law in the microcosm of seed.

Panse (1940a and 1940b) suggested that the study of inheritance of quantitative characters like halo length could be broadly understood for its control for breeding purposes from a study of hypothetical genetic models. Five hypothetical models were studied and the result of selection in F_2 were deduced under the conditions of the models. Of these five models, two consisted of gene-pairs showing no dominance and three showing dominance in opposite directions. By calculating F_3 statistical properties of these models, the effects of these various factors (number of pairs, dominance) on the result of selection were studied. It was found that greater progress was achieved by selection in the absence of dominance and that, in the presence of dominance, greater progress was achieved when only a few factors were acting than when many were responsible for the segregation. It was further suggested that the values of F_3 means and variance calculated from experimental material might be compared with these theoretical values

and guidance regarding the presence of absence of dominance and number of factors acting obtained from such a comparison.

Later Panse (1941) after developing Fisher's idea showed that the problem of inheritance of quantitative characters could be tackled by studying the genetical variability and its further analysis into genetic studies;*i.e.* due to additive action of genes and nongenetic *i.e.* due to non-additive action such as dominance etc., components by statistical methods. A real estimate of the genetic value of the character was sure to be useful to the breeder, who was interested in the genetics of these characters positively for this reason.

Beside the above work, a large collection of genetic types pertaining to different morphological characters have been extracted from enters pecific crosses involving *thurberi* species. These are narrow leaf, laciniated leaf, hairy leaf with high density of long hairs in both sides of the leaf, deep brown on medium lint and lintless.

(3) Inter Specific Hybridisation

A part from the production and possible utilisation of the easily producible hybrids between the cultivated desi species;*viz. G. arboreum* and *G. herbacenm* or between the cultivated American species *G. hirsutum and G. barbadense* ; hybridisation work was undertaken between species of Gossypium, as did not cross readily and if successfully hybridised produce sterile hybrids. Although this line of work could not immediately promise beneficial results; still it also offered to bring results, still it was considered important since it not only helped but also offered to bring under harness some important economic characters such as disease and brought resistance of wild species. Hutchinson crossed the wild African species *G. anamolum* with *G. arboretum* and *G.herbaceumi* and got partially fertile hybrids. Bholanath restored fertility in these hybrids by successively back crossing them to Malvi 9 (*G.arboreum* race*bengalenses*) and established true breeding fully fertile lines for breeding purpose. These lines were characterised by the fineness of their fibre. They were, however, low ginning and poor in kapas yield and as such did not prove useful.

Further, hybridisation of the cultivated *desi* species *viz G. arboreum* with 13 chromosome American wild species *G. thurberi, G. raimondri* and *G. harknesi* was carried out by Ganesan (1946) with the hope of developing artificial polyploids by doubling the chromosome numbers of the hybrids with colchicines. He successfully obtained the doubled allopolyploid between *G.arboreum* X*G.thurberi* called *G.thurboreum.* This was crossed to *G.hirsutum* and *G.barbadense* and F_1progenetic of these crosses and their further back crosses with *G.hirsutum* were allowed to breed till full fertility was restored. At this stage single plant selections were made for good bearing, healthiness and fibre characters.

The local strain of *G.hirsutum,* M. U. 4 was also crossed to *G.raimondri, G. thurberi* and *G. harknessi,* but successful hybrids were obtained only in case of *G.raimondri*. It has 39 chromosome (triploid) and was doubled with colchicines and a hexaploid with 78 chromosomes was obtained. This was further successfully back-crossed to *G.hirsutum* for three times re-storation of the tetraploid (52 chromosomes) condition and then selfed for four generations to restore fertility. On the restoration of fertility single plant selections were made in this material for different plant characters.

(4) General Botany

(i) Study of plant characters and their response to environment:

Knowledge regarding the different plant characters themselves and also regarding their response to environmental changes, is as important as that pertaining to their inheritance. As such work on this aspect of the cotton plant was therefore started very early, and the studies fall under two heads *viz.* those pertaining to analysis and study of plant and seed characters and their response to such environmental conditions.

(i) As occur in nature and

(ii) As are created artificially in the laboratory by seed treatments etc. and manuring in the field.

i. Characters and their Response to Environmental Conditions occurring in Nature

Earliness: Ganesan (1944) studied the problem of earliness in cotton and indicated that a low node number, which was usually considered as an indication of this character was not only a correct index but was correlated with reduced vigour and shorter plant height. He suggested a new "earliness index" on the lines of Bartlett's rate index which involved weighted mean of different pickings and suggested that this had better relationship with all the other factors which constituted the "earliness" of a cotton plant.

Investigation regarding the yielding capacity of selfed and open pollinated seed were carried out in 1932-33 but were inconclusive. Later, however, Ramiah and Bholanath (1944) showed that in case of Dhar 43 (*G. arboreum race bengalence*) the selfed seed gave comparatively lower yield kapas (although not statistically significant) than the open pollinated one.

Root studies: In view of the role of roots in the life of a cotton plant, Ghose (unpublished) surveyed the root systems of the unit species of cotton grown at Indore. As a result of large number of root washings, he concluded that the root systems of different varieties of cotton, at the time of bolling (December-early January) could be broadly classed into five patterns represented by Combodia, (*G. hirsutum* race *latifolium*) Bani, Malvi, Verum

(*G. arboreum* race *bengalense*) and Ghoghari (*G. herbaceum* race *wightianum*) respectively. On the basis of these results it was noted that the Malvi had the best root system, its active rootlets being distributed uniformly throughout the length of its tap root, so that this root taps the resources of the soil equally from all zones. In this respect, it contrasts with Bani which has its absorbing rootlets mostly confined to one zone, *i.e.* the tail end of the system and confining itself to one region and not tapping the whole zone of the soil. Moreover, the *Bani* root system is very shallow and as such not favourably placed to draw nutrient from the soil. These differences account for greater success of Malvi at Indore.

Broach and Goghari studied the long duration late cottons and reported that they have very deep root system admirably suited to the needs of late crop.

Effect of rainfall on halo length and ginning percentage: Similote studied the correlation of rainfall distribution on ginning percentage (1946) of Malvi (*G. arboreum race bengalense*). The study showed that the rainfall in September and October, more particularly the one received in the second fortnight of October tended to increase the ginning percentage. Correlation coefficients for June and August were negative.

Effect of environment on fibre properties: Hutchinson and Govande (1938) surveyed the fibre properties of Indian cotton and found that there was a much greater association of fibre properties with varietal characteristics than environment. It was shown that different botanical group differed greatly in value and fibre properties.

Ramiah and Panse (1941) studied the effect of climatic and soil conditions existing between two localities *viz.* kharua-*adhan* irrigated soil and Indore-unirrigated *barani* land in the fibre properties and spinning quality of Malwa Upland, *G. hirsutum.* It was noted that the fibre length on *adhan* land at Kharua was significantly longer than on *barani* land. Ginning percentage was found to be very variable.

Effect of localities on seed: Ramiah and Ganesan (1946) studied the place effect on Jarila seed produced at Indore, Jalgaon and Akola and found that in addition to the factors affecting seed maturity, agronomic practices of spacing and manuring prevailing in any locality affect the quality of the Jarila seeds produced in the tract. It appears that whichever place produced heavier seed, the seeds from that place gave better performance in its yield in all the places of trial.

Effect of different soil moisture levels: Dhar 43 (*G. arboreum* race *bengalense*) and M. U. 4 (*G. hirsutum*) cottons were grown in post under three levels of soil moisture *viz.* 16%, 24% and 32% by Sreenivasan (1945). It was found that in case of American variety final height of the plant, size

of leaves and transpiration increased with increase in soil moisture percentage. In desi cotton variety, however, number of leaves, leaf thickness, bolls, kapas yield and transpiration were found to be at their maximum with 24 % soil moisture; further increase having deleterious effect.

It was found that for both varieties the transpiration loss at 24% moisture level was significantly greater than at 16%. The transpiration loss of American variety increased significantly with increase in soil moisture from 24% to 32% while the loss decreased significantly in Asiatic variety. It was noted that the water requirement of the American variety is 20 to 40% more than Asiatic variety; while American variety shows better economy of water for producing unit weight to kapas.

ii. Plant Characters in Response to Environment Artificially Created in the Laboratory or Field

Cotton is a crop of economic importance and it was natural that any artificial treatment given to enhance the economic gain from crop should necessarily be such as could be taken up on a large scale. In view of this position, most of the artificial treatments tested in laboratory were restricted to seed alone.

Effect of X-rays on cotton seeds: Efforts were made by Ghose and Bholanath early in 1932-33 to subject the cotton pollen buds and shoots to X-ray treatment to produce mutants; but nothing came out of the same. This discontinued line of work was recommended in 1939 and Ramiah and Bholanath (1945) subjected the selfed seeds of 11 cotton strains (nine *desi* and two *American*) to X-ray treatment of two exposures (10 and 20 minutes) under K. V. P. 65 (M. A. 10) and a target distance of 15 cms. The treated seeds and their progenies not only showed stray mutants for earliness and abnormal growth, but also gave a progeny in M.U 4 which had a distinctly linger halo length and higher ginning percentage as true breeding characters. Repeating the trial of X-raying the seed, it was confirmed that the treatment could be used for improvement of these economic characters.

(ii) Taxonomy and Botanical Surveys

The work of survey, collection, maintenance and classification of the cotton varieties grown in India was taken up immediately after the establishment of the Institute. A larger number of cotton varieties from different parts of India and other parts of the world, were obtained and grown. They were carefully examined for all morphological characters and as a result of which Hutchinson and Ghose (1937) suggested a new system of classification of cotton based on modern concepts of genetics and plant geography, since the older classification of Gamie based on simple mendelian characters created difficulties for taxonomist.

Further, Hutchinson and Ramiah (1938) drew up standard for the description of the morphological and quantitative characters of cotton plant for use of workers all over India. Later, Ramiah (1946) compiled a description of all the Indian cotton strains on these lines

Before the commencement of any improvement work crop survey has always been considered not only useful to know the position and problems of cotton of the tract; but also to collect breeding material. Accordingly, Hutchinson and Ghose (1937) surveyed the cotton of Central India and Rajputana now corresponding to the States of Madhya Bharat and Rajasthan. They gave details of crop composition of the different tracts and showed that *G.hirsutum* formed a major constituent of the cotton crop of Malwa which was a mixture of desi (*G. arboreum*) and American (*G. hirsutum*) species, the latter contributing about 60% to the crop. They also refuted the theory that Malvi cotton had deteriored due to influx of resume from Nimar, but explained that the deterioration was due to the extension of its cultivation on inferior land.

In 1936-37, a botanical survey of Matheo and Wagad cottons of Kathiawar was undertaken and it was established that the range of variation in Wagad was very much greater than Matheo; which was normal in view of the history of these two types. In the circumstances, if a *herbaceum* cotton was to be established in Matheo tract, it was necessary to develop an early maturing type by crossing the local Wagad with early *herbaceum*. Further, it was pointed out that inspite of the variability there was a possibility of its improvement as well.

Ansari (1940) surveyed the cotton crop of Iran on behalf of the Indian Central Cotton Committee and brought a large amount of early maturing *herbaceum* for the Committee. The survey established the fact that the herbuceum in Iran exhibited very great variability in habit, as compared to Indian herbaceum. The *hirsutums* in Iran were grown near the Caspian border and were known to suffer badly due to pests and diseases. It was further, a practice in Iran to top the plants at all stages from bud to boll forming period to hasten maturity.

Ansari (1941) further surveyed the cotton of Baluchistan with a view to enable the Indian Central Committee to formulate its policy regarding the import of Mekran and Baluchistan cotton through Kathiawar ports. It was pointed out that while Mekran grew *herbaceum* cotton, northern and eastern Baluchistan were replacing these by Punjab and Sind American.

(iii) Crop Ecology

During the course of survey of cotton crop of Central India; Hutchinson (1936) noted the association of flower colour and leaf-shape, although there were no linkage between these two loci. It was noted that of these two groups *viz*. yellow flower and broad leaf, were in excess in Malwa, and white flower and narrow leaf groups predominated in Nimar. This position

was attributed to the selective forces that were operating in these two tracts. This was corroborated by Gadkari (1941) who laid out experiments in Malwa and Nimar and concluded that in both tracts the selection pressure was operating in favour of the interaction *Yl yL* over *yl.* Further within the interaction itself broad yellow was at a selective advantage in Malwa. In Nimar, however, there was no difference between the selective value of broad yellow and narrow white, the excess of the latter in the population being due to human effort.

Ramiah and Panse (1941) carried out extensive studies on the growing of mixture *desi* and Upload cottons in order to explain the survival of fairly constant proportion of Upland in Malwa crop inspite of its poor performance and susceptibility to diseases when grown as a pure crop. The two types and their selected strains were grown for a number of seasons with different degrees of competition between them and as pure crops to study the effects of competition on health and vigour of components and also on the quality of the lint produced by them and spinning performance. It was noted that the Upland component and within it the Malwa Upland strains gain in germination, stand and yield and suffer much less from diseases when grown in association with *desi,* than what they do when grown as pure crop. However, the performance of *desi* is practically unaffected by association when compared with individual strain; mixtures were not as disadvantage when compared with individual strain. In matter of fibre properties, mixtures showed better spinning quality.

Panse and Khargonekar (1947) further found that although there was natural selection in favour of the Upland (*G. hirsutum*) to a small extent in mixed population, it was never to such extent as to make it 60% of the total crop. This percentage, was however, being deliberately kept up by the efforts of ginneries. Gadkari and Bhatia further carried out investigations regarding the survival of *G. hirsutum* in Malwa and the behaviour of different cultivated Indian ecotypes of this species at Indore. Their results are in the text of this publication.

Gadkari and Saini studied xerophyily of twenty one Indian cottons by studying their foliar anatomy and their stomata frequency per unit area. They found that varieties of *G. hirsutum* were definitely less xerophytic than Asiatic species *viz*. *arboreum* and *herbaceum*. Their results are also in course of publication.

(iv) General

Apart from the above research work which involved collection of new field data, studies of the already available information from different angles were also carried out for theoretical consideration. Hutchinson (1937) discussed the trends of evolution in the *Genus Gossypium* and cultivated cottons on the basis of facts of their distribution and phytogeography. It was

pointed out that the annual sympodial types were developed from the perennial monopodial types. He also indicated the primary and secondary centres of origin for different cottons.

Hutchinson, Gadkari and Ansari (1937) reviewed the genetic work done in cotton and discussed its bearing on its breeding. They also indicated that, the inheritance of wilt (*Fusarium*) resistance was probably due to the action of simple genes. Ramiah (1941a& 1941b) and Panse (1942) reviewed the progress of knowledge of genetics and plant breeding of cotton and made a plea for further intensive effort in that direction.

Ramiah and Gadkari (1941) discussed the problem of acclimatisation and deterioration of strains and suggested that the seed multiplication itself was to be planned with care.

Ramiah and Panse (1939) discussed the remarks made by Prof. T. G. Mason regarding cotton breeding work done in India and pointed out that the plant breeding methods had definitely progressed in India and not stagnant as indicated by Dr. Mason.

(5) Breeding of Improved Varieties of Cotton

Work on the revolution of improved cotton varieties for the different regions in Central India and Rajputana (now Madhya Bharat and Rajasthan respectively) was conducted as early as 1925.

Simlote (1946a & 1946b) has reviewed the position regarding the cotton problems of the different tracts and the progress made in each case.

It will be seen there from that the cotton improvement problems of the areas served by Institute resolved into breeding improved varieties for Malwa, Nimar, Mewar and Gangacanal Colony regions and the progress made, results achieved for each of them are briefly as under:

(i) Malwa (Madhya Bharat)

The Malwa region, characterised by black cotton of varying depth, and comprising the districts of Indore, Dewas, Dhar, Ujjain, Mandsaur, Shajapur, Ratlam and parts of Chittor, Jhalawar districts of Rajasthan, grow two types of cotton *viz.;* (a) Malwa American, Upland of Cambodia on heavy, partially well irrigated lands known as *adhan* and (b) Malvi or *desi* cotton on barani (rainfed) lands. In the circumstances varieties were needed for Malwa to suit each of these condition and details of the work done for the same are detailed below:

i. *Desi* cotton: The work for the improvement of *desi* cotton of Malwa was commenced in 1924, when a large number of samples of Malvi cotton were collected from different places in the tract and grown at the Institute in the following years. A large number of single plant selection of

Malvense (broad leaf, yellow flower) with superior lint characters such as halo length and ginning percentage were made. By careful selection of superior progenies and elimination of poorer ones years after year; five Malvi strains were developed by 1931. These were tested for their performance in eighteen trials during the period 1932-34 at the Institute and seven other centres in Malwa. Hutchinson and Panse (1936) studied the result of these trials and concluded that in Malwa under barani condition Malvi 9 is the best strain as will be seen from its following average performance (Table 12) over Local Malvi.

Table 12: Performance of Malvi 9 and Local Malvi

Character	Malvi 9	Local
Average yield of kapas (lbs.) per acre	441	380
Average ginning percentage (%)	32.5	28.9
Average of lint (lbs.) per acre	143	110
Average staple (mean halo length) m.m.	23.3	21.6
Average spinning value H.S.W.C.	20's	12's
Value of increased cash return over Local Malvi (Rs.)	Rs. 85	-

As the seed of Malvi 9 was being multiplied, it was noticed that it was highly susceptible to wilt due to *Fusarium vasinfictum.* Efforts were therefore directed towards getting a wilt resistant strain of *desi* cotton which would be on par with Malvi 9 in all other characters if not superior to it.

Secondary selections in Malvi 9 gave five sub-strain but they were all susceptible to wilt. Study of other Malvi selections obtained from Dhar in 1935 showed that one of the families from Bulk 43-Fam 2 was resistant to *Fusarium* wilt and also equal to Malvi 9 in kapas yield and other lint characters. This progeny was therefore taken up and subsequently tested in varietal trials in the districts. It gave consistent performance in addition to its wilt resistance. It was released for general cultivation in Malwa under the name of Bhoj in 1942.

Just when Bhoj was about to be released; Jarila, a strain from khandesh began to infiltrate in Malwa due to encouragement by traders owing to its high ginning and spinning performance inspite of its inconsistent kapas yields in the tract. In the circumstances, breeding programme was directed towards production of strain that would combine the kapas yield and wilt resistance of Bhoj with high ginning and spinning qualities of Jarila.

Accordingly, Bhoj was crossed to Jarila in 1943-44 and the hybrids back-crossed to either parent in the following seasons. Single plant selections were made in this material from F. 3 stage (1946-47) onwards and also from the material obtained from crosses between Malvi 9 Jarila made in 1939-40. A number of true breeding lines like Malvi 10, Malvi 12 and Malvi 17 having high ginning and superior spinning were developed. Their performance however was found to be inconsistent.

ii. *American cotton*:These cottons were grown to the extent of about 60,000 acres on the Malwa plateau; the acreage being mostly situated within and round about Badnawar tehsil of Dhar district. Efforts to improve this American crop were commenced in 1934, when a large number of single plant selections were made in the cultivator's fields and their progenies were tested in the following seasons at Indore. By 1938, two good strains *viz.* M. U. 8 and M. U. 4 were developed, which however were found to be unsuitable as a result of large scale field trials conducted in the tract at Badnawar, during the subsequent seasons. In the circumstances further work of selection and breeding was continued and a new strain Indore 2 was developed out of a progeny, No. 41, obtained from the X-rayed material of M. U. 4 (Ramiah and Bholanath 1945). This new strain has a staple length of 15/16″ as against 27/32″ of Dhar Cambodia. It not only yields, gins and spins better than the local Cambodia, but resists letter with jassids and red leaf.

(ii) Nimar (Madhya Bharat)

This is the most important cotton growing tract of Madhya Bharat cultivating about 3,00,000 acres annually under the crop and as such its immediate improvement was a pressing necessity.

Prior to the commencement of actual breeding work in the tract at Dhamnod in 1934, which was made possible due to the facilities offered by Dhar State. Field trials of ready-made cotton strains from the adjoining state were conducted in the tract at five centres during the period 1932-34. Studying the result of these trials Hutchinson and Panse (1936) could not come to any conclusion, regarding the suitability of any of the strains tested.

In 1936 a large number of single plant selections were made in the cultivator's field in Nimar. These together with the other promising ones already at hand in Indore were planted and as a result of regular selection and breeding during successive seasons two families *viz* .I 6 and S 6 were developed by 1938, Simlote (1946) and were ready for large scale trial in the tract. Further work on these, however had to be abandoned since these strains had a much lower ginning percentage than the new Khandesh variety Jarila which had by then infiltrated in the tract and found great favour with the trade. In the circumstances, it became incumbent that the new improved

strain for Nimar should be on par with Jarila in matter of ginning and spinning qualities. Work had therefore to be started afresh to evolve a strain which could yield as much as local Nimar and gin and spin equal to Jarila. A large number of fresh single plant selections were again made in the tract in 1939 and tested in the following seasons. None of them however came up to the mark. Subsequently, the material from the crosses of Malvi 9 and Bhoj with Jarila made in 1939 and 1943 arespectively at Indore was put up for trial at Dhamnod. A new strain D 48-154 now called a*Maljari* has now been evolved from M 9 x Jarila cross. This strain yields kapas and lint per acre more than Jarila and its successor Virnar (197-3). The average performance is detailed in Table 13.

Table 13: Performance of D 48-154 and other improved strains in Nimar

Strains	**Average yields of kapas**	**Average Ginning Percentage**	**Average lint yield per acre**	**Average Fibre length**	**Average Fibre weight**	**Average H.S.W. C.**
D 48-154	576	36.7	208	0.86	0.174	30′s
1973	483	38.9	185	0.84	0.184	24′s
Jarila	405	32.0	130	0.86	0.168	28′s
Local Nimar	367	33.5	110	0.83	0.156	28′s

Efforts are now being made to multiply the seed of this variety under the name Maljari for distribution to the cultivators.

(c) Improvement in other Crops

(1)Wheat

(i) Plant Breeding: As a result of selection from different wheat growing areas of Madhya Bharat in 1934-36, a few improved strains *viz.* R-14 (a red grained type) and EK-69 (a white grained type with bold seeds) from amongst the *T. durums* and N-34 from amongst the *T. vulgare* were evolved and distributed to the cultivators. Another strain namely N-111 was selected which beloned to *T. turgidum* species.

Another set of improved strains of *T. Durum* type's *viz.* F. 16, F.37 and F. 72 were evolved from selections made in 1939. F. 16 was found to be most outstanding.

In order to evolve Black rust resistant varieties of both *T. durum* and *T. vulgare* species, crosses were made between Local types and rust resistant exotic types in 1946-47.

(ii) Biometrical Genetical Studies:

i. Heritable variability: Genetical variability was assessed in sample of local *durum* wheats collected from different place in the Malwa plateau. It was found that out of 16 samples, only two from Jhabua and Barwani had sufficient variability in response to selection.

ii. Discriminant function for durum wheats: These function were worked out on:(i) samples of durum wheats obtained from Bengal, Madhya Pradesh, Hyderabad, Bombay, and Madhya Bharat and (ii) bulk of selected progenies from Local Malvi wheats.It was found from function for (i) that number of tillers, weight of 100 seeds and weight of straw were positively correlated and number of ears per plot and number of grains per ears were negatively correlated with the genetic yield of the samples. The expectation of genetic advance was 16.4% when all the five characters were considered and only 5.2 %, when tillers were omitted. Function fro (ii) showed that number of tillers per plant weight of 100 grains and number of grains per ear were positively correlated and number of ears per plant was negatively correlated with genetic yield. The expected improvement over ordinary selection would be about 10%.

iii. Development of tillers and ears of wheat varieties:

(i) Tiller development of six varieties *viz.* Dhar selection R-42 (institute), Bansi 168 (Bombay), C.P. 137-7 (Madhya Pradesh), and Hyd. 557-10 (Hyderabad) were studied for two seasons (1941-42 and 1942-43). Institute varieties developed more tillers and the rate of development was also quicker than the outside varieties.

(ii) The commencement of ear emergence synchronised with the period of maximum tillering, that is, sixty days after sowings. Like tillers, the rate of ear development was studied graphically and it was found to be different tin different varieties. This rate was also highest in the Institute varieties.

(iii) Number of grains per ear was found to be lowest in the Institute varieties but their weight of 100 seeds was higher than the outside varieties.

(iv) Vernalizing the germinated seeds of Malvi wheat (*T. durum*) and Pissi wheat (*T. vulgare*) did not have any effect on the yield of grain of these varieties, though there was slight increase in number of tillers and ears produced by them.

(2) Jowar (Sorghum)

Jowar improvement was started in 1934 and a large number of single plant selections were made in the field. Mass selection in the form of 'compartment selection' was also adopted. As a result, two strains, viz. I. P. 3 and I. P. 9 were developed by 1946. I.P. 3 is characterised by loose ear head and white grain (chalky), and I.P. 9 has pearly yellow grain and

compact ear head.Further improvement of these strains was attempted from 1946 onwards by secondary selection which did not yield good results.

(3)Gram (*Cicer arietinium*)

Gram (*Cicerarielinium*) is an important rabi legume in Malwa and occupies an area of about 5 lakh acres in Malwa. Earlier trials of "ready made" strains from the neighbouring States showed that none of them was superior to Local Malvi gram in yield of grain (Hutchinson and Panse 1936). Latter on, single plant selections were made in the cultivators's fields and one of the selections, *viz,;*Indore 707, though was at par with the local gram in yield of grain, was resistant to wilt and matured a fortnight earlier.

Side by side, study of genetic variability in the local gram samples collected from different states of Malwa was taken up but it could not be completed on account of poor germination under *barani* conditions. Hybridisation with a view to study the inheritance of seed coal and cotyledon colour was also undertaken at the Institute, but this could not be competed on account of poor germination of the F_2s under *barani* condition. Phadnis (1946) observed xenia in cotyledon colour in crosses between black and green coat types with yellow and green cotyledon colour occur in the same F_1 plant.

Improvement in yield of grain was continued and another strain, I. P. I. 22 was evolved by single plant selections which was superior to I. P. I. 707 in yield of grain by 10%. These two strains have been multiplied and distributed to the cultivators of Malwa since 1943.

(4)Tuar (Pigeon pea)

Tuar (*Cajanusindica*) is also an important kharif legume in Malwa and occupies an area of about 2 ½ lakh acres annually. Single plant selections were made as early as 1934 in Malvi Tuar and by means of replicated progeny row tests a strain known as I. P. I. 5 was evolved which was superior to the local Tuar by 20% in yield of grain and had uniform grain colour and size and earlier in maturity by about 10 days. This strain was sweet in taste and can be cooked easily. Hence this strain was multiplied and distributed to the cultivators of Malwa since 1941.

(5)Linseed

Trial of strains evolved in different states of India that none of them was better than the local linseed which is extensively cultivated during rabi season in Malwa. Single plant selections in the field crop resulted in the evolution of 3 strains, *viz.* I. P. I. 6, I. P.I. 65 and I. P. I. 11; the first two being brown seeded, and the last being white seeded. The brown types yielded better than local but were susceptible to Fusarium wilt. Subsequent selection and trials since 1946 have shown that Mahoba from U. P. was superior, so far as seed characters were concerned. N. P. 11, another yellow type, is on par with I.P.I. 6 in yield but disease resistant and therefore is being recommended.

(6)Groundnut

Trials of type collections from the various states in India, have indicated that only the Spanish types having the following group of characters are better adapted to the rainfed Malwa conditions :

Erect, large light green leaves, very early, small pods and seeds, and high shelling percentage. Two of these types;*viz.* Exotic 5 (strain 6608 from Argentina) and Exotic 7 (Barberton from South Africa) are the best and their performance is as below (Table 14).

Single plant selections in some of the more promising types were done and their progenies were tested. One selection from T. M. V.-2, a Madras type, appears to be better than control in the preliminary trials.

Table 14: Performance of Exotic 5 and Exotic 7 strains of Groundnut

Growth Charaters	Exotic 5	Exotic 7
Yield of pods; lbs per acre	649	767
Shelling percentage (%)	67.2	68.5
Yield of kernels, lbs per acre	448	544
Oil percent (%)	48.5	46.3
Yield of oil, lbs per acre	218	246

(d) Agronomical investigation on different Crops

(1) Cotton

(i)Effect of humus supply on the yield of cotton:

In 1933 manures were mixed throughout the profile down to morum (18-24 inches depth). These plots were further supplied with organic manure at 10 tons per acre in 1934. In both the season the yield of cotton increased substantially due to profile manuring and Malvi 9 responded better than Indore I. These plots were further manured with 200 maunds* of compost per acre and were occupied by tobacco crop in 1935 and by cotton in 1936. The manurial plots maintained their superiority to control by giving higher yield of cotton.

A brief summary of the results of manurial experiments carried out on cotton from 1936 to 1939 are as under:

With very exception both artificial nitrogenous fertilizers and organic manures produced a good response on the more fertile fields and a very

much smaller or on no response on poor fields. This result is apparently contrary to the expectations that poor field should be more responsive to manuring than richer fields. Here the poor fields are characterised not so much by poor drainage and water-logging which interface with the growth of cotton plant and its capacity to respond to manuring. It was also found that in poor field the response was closely related to the total amount of rainfall and its distribution, as due to high proportion of clay in the black soil, its drainage is rapidly impended through frequent heavy showers.

As to the effect of manures on better fields there was an increasing response to increased application of nitrogen. An average increase of 102 lbs in the field was obtained for a dose of 50 lbs. N in trial carried out in 1937 and 1938. In a trial carried out in 1939 the increase was as high as 192 lbs. for an application of 40 lbs N. Phosphate and potash, however, showed no effect. Compost frequently gave a small but significant increase in the yield for quantities supplying 18 to 50 lbs N per acre. Groundnut cake also gave promising results. Amongst other cakes, linseed cake gave good increases in the yield while til-cake was not effective.

In two experiments drilling the manure was compared with broadcasting and in other three, different times of application of manure were tried. The results were not conclusive in either case but there was an indication that drilling might prove effective. With regard to the time of application there is little possibility of gain by delaying the application of nitrogen either in part or full beyond the sowing time.

In the year 1943-44 the effect of compost or fired soil applied at 3 tons and 6 tons per acre to cotton was studied in a poor field. The application of compost increased the yield significantly with a corresponding increase in the doses while the increase in yield could not reach the level of significance due to the addition of fired soil.

(ii) Effect of fired and gray soil on the yield of cotton:

In 1939-40 both fired and gray soils were used as soil improvers in eroded field. The treatments consisted of (i) untreated control, (ii) 6 inches surface soil replaced by loose gray soil, (iii) 6 inches surface soil replaced half with fired soil, (iv) fired soil in a 3 inches layer mixed within half the soil removed from two 9 & inches deep trenches, (v) six inches layer removed and ¼ portion replaced by gray soil and again filled in. The full gray soil gave significantly higher yield of cotton than other treatments out of which half fired soil mixing gave better yields than the rest.

In a similar experiment in 1942-43 six inches surface soil was replaced by gray soil in full, half and one eighth. The result have shown that replacing the 3 inches of black soil with gray soil was the best and increased the yield of cotton nearly 11/2 times the control.

(iii) Effect of surface thickness on the yield of cotton:

Loose surface soil was spread in poor and rich field in layers, one inch, 2 inches, 3 inches, 4 inches and 5 inches thick from the same field and in 2 inches and 5 inches, thick layer of soil from another rich field and their effect was studied on the yield of cotton. The application of loose surface soil from the same field increased the yield of cotton in both the field. In rich or well drained field there was no appreciable increase due to 2 inches layer while in the poor field the yield increased with thicker layer and 5 inches layer of surface soil gave the highest response.

(iv) Crack formation in black soil:

In 1942-43 a study of crack formation in black cotton soil in relation to its fertility revealed that there are more cracks in rich field than in poor field. It is a natural process of cultivation and therefore it is better to (i) avoid cultivation during summer fallow except when it is badly infested with weeds and (ii) allow cotton plants to remain in the field till middle of may.

(v)Effect of graded doses in the form of Ammonium Sulphate and groundnut cake on the yield of cotton, its maturity and loss of Ammonia:

The experiments were carried out for three seasons (1943-44 to 1945-46) in two fields; rich and poor, where *desi* cotton was manured with Ammonium Sulphate and groundnut cake each at 20, 40, 60, 80 and 100 lbs N per acre. The manures were drilled or broadcast at the time of sowing. The results have shown that the yield of cotton increased with an increased dose of nitrogen in both the fields and 20 lbs. N gave the highest yield. However, the magnitude of response due to nitrogen application was much higher in rich field than that of poor field. In general the two manures did not differ significantly in their response in spite of the fact that loss of Ammonia from Ammonium Sulphate was higher than groundnut cake. Drilling the manure seemed to be better than broadcasting as the former helps to minimise the loss of Ammonia and consequently gives higher yield. The application of nitrogen also induces early maturity in the crop.

(vi) Effect of soaking cotton seeds in nutrients solutions:

Cotton seeds were soaked in different chemical nutrients like Cerasan, Nomerson and Levulenic acid with one and five per cent solution. None of the treatments was found to be effective to accelerate germination.

(vii) Effect of sowing time on the yield of Cotton:

In 1933-34 *desi* and American cottons were sown in dry soil before the advent of rains and at the normal time with the onset of rains. In *desi* Cotton premonsoon sowing did not increase the yield significantly over the rain-

sown crop while American type showed a tendency to give higher yield with premonsoon sowing.

(viii)Effect of spacing on the yield of Cotton:

Spacing of 24 inches between rows and 8 inches between plants and 12 inches between rows and 3 inches between plants showed no significant difference in the yield of Cotton in 1933-34.

(ix) Effect of topping on the yield of Cotton:

In fertile soil with vigorous growth topping of cotton plants before the budding stage has a favourable influence on the yield while under poor soil conditions, such influence was not observed. Topping after budding stage had adverse effect on the yield.

(x)Effect of cultivation on the yield of cotton:

The experiments on cultivation were carried out in 1933-34, 1934-35 and 1937-38 when shallow and deep cultivation with different implements was compared. The results have shown that there is no advantage due to deep cultivation for Cotton crop and winter cultivation also has no bearing on the yield of cotton.

(xi) Effect of interculture on the yield of Cotton:

Experiments were carried out in 1934-35 and 1942-43 to study the efficacy of different implements for weeding and hoeing in cotton and it was found that hand weeding is the best method of removing weeds to get higher production.

(xii)Effect of seed size on the yield of Cotton:

The results of the trial conducted during the year 1946-47 gave the indication that the yield of cotton can, to a certain extent, be increased by using heavy and large-sized seeds.

(xiii)Associated growth of cotton with Legumes:

The experiments on the associated growth of cotton and groundnut were carried out in 1942-43 and 1943-44. In these trials a few rows of Cotton were grown alternating with few rows of groundnut. The results have shown that in such mixtures the yield of cotton is much lower as compared to cotton alone while the yields of groundnut are not substantially affected as compared to groundnut alone. The intercropping of these crops fetches higher money returns than groundnut alone when 2 rows of cotton are grown alternating with10 rows of groundnut.

(2) Other Crops

(i)Jowar (Sorghum)

Intercropping of Jowar with Tuar:

A replicated experiment was laid out at institute in 1932-33 where Jowar was intercropped with Tuar. The results have shown that interpolation of Tuar in a Jowar crop is more profitable than Jowar alone.

(ii) Sugarcane

1. *Effect of sett soaking in lime water before sowing (1935-36):*

Sugarcane setts were soaked in one per cent lime water before planting. The germination and yield is greatly improved by the treatment and the crop also matured earlier.

2. *Manuring:*

In the year 1935-36 two varieties of sugarcane, Co. 213 and Co. 290, were manured with one and two units of compost supplemented with one or two units of artificial manures. The manures were applied before planting as well as before earthing. Co. 213 yielded better with one unit of compost in combination with two units of artificial while Co. 290 gave highest yield with two units of compost supplemented with one unit of artificial manure.

(iii) Rice

In an experiment on rice carried out under irrigated conditions in 1934 the effect of manuring with 20 and 40 cart loads of municipal compost and one and three cwt. of Niciphos 22/18 and 17/45 were studied on the yield of transplanted paddy. The planting was done early and late in the season. Early planting with application of higher doses of manures gave remarkable increase in the yield as compared with control.

(iv) Wheat

Effect of tillage and interculture on wheat:

The experiment was carried out in 1932-33 to study the effect of interculture and different types of preparatory cultivation on the yield of *durum* wheat. The preparatory cultivation included (i) *cross* ploughing 3″ to 4″ deep with a *desi* plough, (ii) ploughing 6-7 inches with an inversion plough and (iii) no cultivation. These were followed by two bakharings. The yield of wheat was not increased either by interculture or different preparatory operations.

Effect of compost and fertilizers on the yield of wheat:

In 1934 a preliminary experiment was conducted on two fields one with defective drainage and another with good drainage to test the efficacy of

farm compost and municipal compost for increasing the yield of wheat under *barani* conditions. The composts were applied at 20 cart loads per acre equivalent to 78 lbs. N per acre before rains and after rains before sowing wheat. The results have indicated that significant increase in the yield of wheat was obtained from the field with defective drainage, with post rain application of farm compost and pre and post rain application of municipal compost. On well drained field with better texture increase due to compost application was not so pronounced.

Experiments on wheat EK 69 or C 591 grown under *barani* condition were conducted from 1944 to 1947 to study the response to the application of Ammonium Sulphate and groundnut cake each applied at 20, 40 and 60 lbs. N per acre, with and without Superphosphate at 20, 40 and 60 lbs. P_2O_5 per acre. The results have shown that wheat responds to fertilizer application under *barani* conditions, provided the rainfall is favourable and the combination of N and P gives better response than either of them if applied alone.

Effect of green manuring on the wheat under rainfed conditions:

Since 1932 the experiments had been in progress at the Institute to find out (i) the best leguminous crops to be used for green manuring (ii) the stage at which the crop should be buried in the soil and (iii) the method of manuring the field.

Best leguminous crop as green manure:

In 1932 four leguminous crops viz. black gram *(Phaseolus mungo)* var radiatus Cowpea (*Vigna catiang*), Sunhemp (*Crotolaria juncea*) and Soybean (*Glycine hispida*) were first tried for green manuring. These crops were either cut or removed or buried in situ at flowering stage and I.P. 4 wheat was grown on these plots. It was found that the plots from which green matter of black gram was either cut and removed or buried gave highest yield of wheat and this was significantly superior to yield from plots, where Cowpea was buried and Soybean was cut and removed. The yield from other treatment plots did not differ significantly from that of fallow plots. Although the yield from Sunhemp plots was not significantly higher than fallow but the amount of green matter produced was the highest.

In 1935 Sunhemp was compared with Cowpea alone under different methods of green manuring in two fields; one well drained and the other poorly drained. Green manuring with Cowpea gave higher yield of grain than Sunhemp manuring on both the fields. The effect of green manuring with Sunhemp was more pronounced on well drained field, than on poorly drained field.

Stage of burying the green manuring legume:

Sun was ploughed in at seedling stage, growing stage (8 weeks old) and flowering stage in 1933, 1934 and 1935, respectively. Cowpea and Sunhemp were buried after six, eight and eleven weeks of sowing. The results indicated that better yields of wheat could be obtained if the green manuring legume was ploughed in either at growing or flowering stage, provided there was good rain following it.

Method of green manuring:

The methods tried for green manuring were (i) Burying in situ, (ii) Cutting and removing, (iii) Cutting and speading in the same field, (iv) Cutting and burying in previously open furrows and (v) Composting green matter and adding.

(v) Tomatoes

Three varieties of tomatoes viz., Meeruti IC 91, Hybrid 6 and Sioux BC 2598 were tested under local conditions. The first was found best in yield while hybrid 6 was the sweetest in taste.

(vi) Koorka (China Potato) (*Coleus parviflorus*)

The seeds of this tuber were obtained from Kumta farm, N. Kanara for testing their suitability under local conditions. The crop thrived well under Malwa condition.

(3) Miscellaneous

(i) Controlling the soil erosion:

Land grading with open drains have been found quite effective for preventing erosion of surface soil and the strip cropping with low spreading crops as contour strip barriers across the fields and planting of low spreading hardy bushes on field margins were found effective for retarding the force of water.

Experiments were also carried out to prevent soil erosion by growing groundnut and cotton across and along the slope in alternate strips by rotation but no definite conclusion could be drawn from 2 to 3 years trials as such experiments need be planned for quite a long period.

In a third experiment open surface drains with shallow furrows were provided at different space intervals between the rows of growing cotton with a view to improve water logged condition by regulating drainage and soil aeration. As a result of 3 years trial water logged condition could be improved.

(ii) Eradication of weeds:

Eradication of kans (Saccharum spontaneum).

i. Kans which is an obnoxious weed in Malwa could easily be smothered by covering the infested surface with green grass or growing crops like Velvet bean or Sunhemp.

ii. Kans could also be wiped out completely by bakharing at an interval of 7 or 14 days for a period of 8 to 10 months.

(e) Statistics

The application of statistical methods for the investigation of problems relating to agriculture research was started practically from the beginning of that the Institute of Plant Industry. At time the work of this branch consisted mostly of planting trials at the Institute as well as at various stations of the former States of Central India and Rajputana which were contributing members of the Institute. Data collected from these trials examined statistically and the conclusion drawn from such an examination were used as a guide for future experimentation.

On account of growing importance of the science of statistics in agricultural research, special & investigation & were undertaken from 1933 onwards. These investigation can be divided into two groups viz., (1) Fundamental research and (2) Problems of immediate practical importance. The results obtained from the studies carried out under the above two categories are briefly summarized below:

(1) Fundamental Studies

(i) Field technique:

Studies on the technique of field experiments were carried out with the help of uniformity trials conducted at the Institute as well as at other experimental stations. Most of these studies were on cotton crop although a few trials were available for Jowar, Paddy and Jute from other stations. These investigations were aimed at in studying the optimum size of plots and the block and the efficiency of various incomplete block designs for varietal trials with respect to simple randomized block. The most important achievement under this subject was the development of the two designs viz.; (1) Replicated Progeny Rows and (2) The Compact Family Blocks for breeding trials.

These studies showed that :

a. Long and narrow plots of 1/40 acre size posses accuracy for cotton varietal trials.

b. Latin Square design was less efficient to the extent of 10 to 23 per cent as compared to simple randomized block design for cotton varietal trials.

c. A block of compact shape was observed to be most efficient, having rectangular shape for equal areas.

d. In harvesting produce from experimental plots, it is necessary to leave 2 rows on either side with 2 to 3 feet length at each end of the plot to avoid border effect.

e. For hand sown experiments on cotton compact blocks without any 'control' plot were found to be more efficient by 15 to 20 per cent comparison to the 'strip' arrangement with 'control' plots at regular intervals.

f. The modern incomplete block design were found to be more efficient than simple randomized block layout by 10 to 50 per cent for varietal trials of Cotton, Jowar, Paddy and Jute when the size of the plot was more than 50 square feet and the experimental land was not homogeneous in fertility. Amongst the various factors that enter into a field layout of incomplete, block design it was observed that the degree of efficiency of these designs largely depended upon the size of the plot, the correlation co-efficient between the two variates being observed to be 0.36. The joint effect of plot size and shape, incompleting and complete block shapes and the standard deviation per cent on the efficiency of double lattice designs was studied and the multiple regression co-efficient was observed to be 0.48 which was significant.

The investigation regarding the estimation of missing plot values in split plot and strip designs were carried out and algebraic expression were developed for this purpose.

(ii)Application of statistical methods for the study of inheritance of quantitative characters:

In this field of research the Statistical Section of the Institute can be said to be pioneer in this country in making use of statistical methods for the study of quantitative inheritance, which were mostly applied formerly to the qualitative studies. The importance of genetic variability and its estimation in plant breeding experiments for the study of quantitative inheritance of characters such as yield, ginning percentage, staple length in cotton crop, was brought out from various experiments, carried out at the Institute of Plant Industry by Dr. Hutchinson and Dr. Panse. These studies showed that :

a. The estimation of genetic variability by regression method of adjusting progeny means on parental values can be recommended for crops which are not self-fertilized and the estimation of the same

variability can be done with fairly good degree of accuracy from the analysis of variance in case of self-fertilised crops.

b. Formulas for the estimation of genetic component of the total variability observed in the population under study were developed and are being extensively used by plant breeders.

c. Genetic models explaining the dominance of the character under study were developed particularly for the staple length of cotton crop. Effective numbers of factors were worked out for staple length.

A discriminant function for selection for yield in cotton was attempted for application with the help of four characters viz., (1) number of bolls per plant, (2) number of seeds per plant, (3) weight of seed cotton per seed and (4) ginning percentage. The function was, however, observed to be less efficient than straight selection as the genetic advance estimated by the function was very small.

A study of potentialities of different arboreum crosses with regard to their possible combination of economic characters was undertaken in the year 1940-41 by making crosses between 11 and superior and 9 inferior strains of *arboreum* cottons. Significant heterosis in yield, staple length and vigour, as measured by the height, were observed in F_2 generation. Six crosses out of the possible 99 combinations available were continued upto F_1 generation by selecting progenies in successive generations, with long and short staple length. It was observed that upto F_9 generation the staple length of the selected crosses continued to show increasing trend for long staple progenies. The percentage increase in maximum halolength observed in F_9 generation as compared to that inF_3 ranged between 26 to 43. In F_{10} and F_{11} generations therewas a decrease in the staple length which was attributed to seasonal conditions and was corroborated by similar decrease in the parental progenies. The short staple progenies did not show any consistency in their staple length.

From the material mentioned above fresh crosses made in F generation between (1) high and low lines, (2) within high, and (3) within low lines of selected crosses. It was observed that the gross variability was high in the first category of crosses as was to be expected, but in crosses made within low lines, also the amount gross variability was appreciable.

An important observation made from the data on yield and maximum halo-length of the selected crosses was that of the existence of positive correlation between the two characters in successive generation. The magnitude of this correlation was, however, not high and had a range between 0.20 to 0.80 in the individual crosses and from 0.20 to 58 for all the crosses taken together.

(iii) Theoretical investigation:

Under this section investigations on special problems that were carried out by the post-graduate research workers for their M.Sc. degrees are mentioned. These problems were :

a. The application of Fisher's 'Z' test for testing the variation in yields of mixed crops such as irrigated and non-irrigated and mixtures of two component crops like wheat and gram or wheat and barley, that are usually obtained in the data collected by random sampling method in surveys for estimation of yields.

b. In sample surveys it is necessary to check the work of field staff for which a party of investigators is appointed. The cost that is incurred by these investigators enters in large scale sample surveys and different methods to reduce this cost, without lowering the accuracy of the estimates appreciably, are suggested by the method of interpenetrating samples. A detailed study on the efficiency of different systems of interpenetrating samples, with special reference to the cost was carried out at the Institute of Plant Industry for the data collected on Jute crop in Bengal. It was shown that the method of interpenetrating samples gave a loss of about 21 per cent in the information which could be reduced to a range of 8 to 17 per cent, when the samples were independently located and then grouped in two sub-samples.

c. A mathematical relationship between the degree of efficiency shown by incomplete block designs, with respect to randomized blocks and intra class correlation coefficients from small and large-sized blocks was established. It was shown that the relationship was not linear, but of a complex nature involving higher powers of the two interclass correlation coefficients.

d. Ten percent probability level tables of the variance ratio (F) were computed for the use of breeders so that they can be used in plant breeding trials for selection purpose in place of 5 % tables which might sometimes cause rejection of the material on account of the higher level of accuracy used for the test of significance.

e. Genetic models were constructed for the genotypic system involved in the staple length of cottons.

(2) Investigations of Practical Importance

(i) Manurial Trials:

A review of manurial trials on cotton (Panse, 1946) was carried out for investigating the rate of response of cotton crop to graded doses of nitrogen. On the basis of this review, manurial trials were carried out under rainfed

conditions at various research stations located in black-cotton soil tract of Peninsular India. These trials were spread over a period of four years (1942-43 to 1946-47) and were intended to study the efficacy of Ammonium Sulphate and groundnut cake, when applied in grade doses of nitrogen for increasing cotton yields. Two methods viz., drilling and broadcasting were tried for the application of manures.

(ii) Physiological studies:

The crop census studies carried out by Hutchinson and Ghose (1937) revealed that the components of the mixed local cotton viz. American and Desi were in a stable equillibrium of 60 to 40 per cent, respectively. This led to the belief that the American cotton might be gaining some advantage by its competition with the Desi. In order to secure experimental evidence on the above aspect trials were started in 1935-36 season at the Institute of Plant Industry, Indore and were continued for a period of about five years.

The object of the trials was to study the effect of competition on the yield of component crops and their plant and seed population. The results obtained from these experiments are briefly summarised below:

(a)Effect on yield:

It was observed that when the crop was sown as mixture of two components the total yield was maximum followed by that obtained, when sown either in one or two alternating rows of the individual components. The yield was lowest when the two components were sown in the pure form.

(b)Effect on plant and seed population:

For this study different proportions of seed viz.; 75:25; 50:50 and 25:75 of Desi and American varieties respectively were formed for sowing. The seed obtained from these proportions was used for sowing in subsequent seasons. It was observed during the course of four years that the proportion of Desi plants rose very high and practically reached the same level in all the three treatments.

These results showed that although the American gained as a result of growing it in mixture with the Desi the high percentage of this component observed in the total crop was not due to natural causes but was a result of the outside agency responsible for mixing it to suit the traders for getting a desired quality of lint. This was further confirmed by the spinning values of lint obtained from crop grown in different proportions of mixture.

In addition to the above studies, a special investigation was carried to study the effect of weight and size of seed on the yield of cotton crop. The results showed that heavy and large-sized seed gave about 14 per cent higher yield of Kapas as compared to the yield from bulk seed.

(iii) Sampling Studies:

These studies were carried out in the Statistical Section for finding the efficiency of different patterns of samples located in field experiment with a view to draw conclusions for relative performance of treatment assigned to the whole plot. In experiments including large number of plots, such as those available in the long term rotational trial, referred to earlier, sampling was introduced as an alternative to the harvesting and processing the produce of the whole plot so as to avoid the storage difficulty as well as to reduce the cost of lay out and time required for the above operations of the whole plot. The results obtained from these studies have been reported in various publications and can be briefly summarised below:

(a) Sampling studies for the estimation of character values in field experiments showed that 5 to 10 plants or 2 to 5 observation rows, each of 3 to 4 feet length. Distributed at random in the plot, were quite satisfactory for sampling in the study of characters like height, number of fruiting nodes number of bolls and the intensity of infection due to '*leaf roll*' and '*red leaf*' attack in cotton crop.

(b) A rapid method based on drawing random bunches from a combed seed was suggested for adoption to find out the fibre weight of cotton for relative comparisons in a plant breeding programme. The results of this investigation have been published.

(c) For measurement of staple length of cotton, 5 to 10 random seeds were found to be sufficient to attain a fairly good degree of accuracy. The average staple length thus measured had a high correlation with the spinning value of cotton.

(d) Sampling studies were carried out in wheat and jowar crops to find out whether sampling can be used on an alternative to the harvesting and processing, the produce from the whole plot. The results of 5 years data showed that sampling can be used with advantage in wheat crop where in 20 to 70 percent information per unit of cost can be gained as against the cost and labour involved for the above operation of the whole plot. In Jowar crop, sampling did not prove to be advantageous.

Besides, the above important investigations, sampling studies were carried out on other topics like hand spinning, estimation of observer's bian in measurement of staple length of cotton etc.

(iv) Sample surveys for estimation of yields:

Sample surveys for estimation of cotton yield on Madhya Pradesh were planned at the Institute of Plant Industry. These surveys were supervised by the staff members of the Statistical Section who also carried out the Statistical analysis of the data collected from them. In addition to this a

special scheme, sanctioned by the Indian Council of Agricultural Research for improvement of agricultural statistics, was operating for a period of one year. The Statistical Section was responsible for collecting data and analysing it. A comprehensive report suggesting various measures for improving agricultural statistics was submitted to the Indian Council of Agricultural Research and has been published by that body.

The crop surveys, besides giving estimation of per acre production, were helpful in getting ancilliary information regarding different agronomic practices adopted in the tract for cultivation of cotton crop. Data collected from sample plants were used to set up regression equations for forecasting cotton yields.

A special study was carried out to fix a plot size for estimation of cotton yield and it was shown that small plots of $1/2000^{th}$ to $1/200^{th}$ acre gave over estimation to the extent of 20 to 40 per cent in yield. A plot of $1/20^{th}$ acre size was found to be ideal for estimation of cotton yields.

The principle of sample surveys was used in the estimation of response of Jowar crop in the intensive cultivation programme of distributing improved seed and manures in the adjoining village of the Institute. It was shown that the estimates of response obtained by this method agreed fairly well to the results of the experiments carried out at the Institute.

(v)Meteorological studies:

A statistical study of the distribution of rainfall at Indore was carried out with the data of 24 years (1924-1947). It was observed that the rainfall at Indore behaves in a cyclic manner, there being a progressive rise for a period of seven years after which a progressive decrease was observed for the next period of seven years.

Upper and lower limits of rainfall received during each week of monsoon period were worked out, which helped in determining the optimum time to be adopted for starting the sowing operation of Kharif crops. A period between 15^{th} to 20^{th} June has been considered to be optimum for this purpose.

It was also observed that the average rainfall recorded at the Institute observatory was significantly lower by about 2 inches as compared to that recorded in the city.

A tabular schedule has been prepared to show the arrangement of treatment plots for confounded designs used in factorial experiments. The table shows the actual effects that get confounded in small blocks of various sizes, the loss of information resulting from the arrangement and the number of replication, necessary to recover the loss of information. These tables are useful for agronomical experiments and serve as a ready reference.

(f) Entomology

The work of the Entomology Section at the Institute was started in December, 1946 with the appointment of the Entomologist. The first two year were devoted mostly to teaching the Diploma Classes, collecting information about the problems and collecting the insect specimens. Two tours were also undertaken to various States then existing in Rajasthan and Central India, in advisory capacity and also to study the insect problems of the places. After the reorganisation of the Princely States and formation of Madhya Bharat more attention was paid to local problems and to finding out control measures against the insect pests of this tract. Cotton being one of the most important crops of the region with a fairly large number of insect enemies, more attention was given to this crop than to others, as advised by the local Agriculture Department. There was no other staff in the section except the Entomologist. Observations taken during the period and work done on each crop are given below:

(1)Cotton:

It was found that cotton was being attacked by a large number of insects.

American types were more susceptible to insect attack than the desitypes. Observations were therefore mainly confined to the Americans. The chief pests noted were (1) Jassids (*Emposca spp*.), (2) Aphis (*Aphis gossypii,* G.); Fig.16,(3) Leaf roller (*Sylepta derogata,* F.), (4) Semi loopers (*Cosmophila* and *Acontia spp.),* (5) The Spotted bollworm (*Earias fabia* Stoll) and (6) The Pink bollworm (*Platyedra gossypiella,* Saund). Besides these the Red and Dusky cotton bugs (*Dysdercus cingulatus,* F and *Oxycaraenus latus,* K., respectively), the Semi-looper (*Tarachae nitidula,* F.), Thrips (*Thrips tabaci,* L.) and red mites (*Anychus latus* C. & F.) were also noted to appear and do damage to the crop, occasionally. *Earias insulana* Boisd was present in small numbers and *Heliothis obsolets* F. in very small numbers attacked the buds, and bolls. Prodenia also was occasionally noted to do damage to the crops. Other insect pests in very minor role were the shoot roller *(*Phycita in fusella, M) the Mylocerus weevil and the wooly mite. Grass hoppers noted include (*Cyrtocanthacris ranacae,* S.) and *Acolopus* and *Chrotogonus spp*. The stem borer (*Sphenoptera Gossypii,* K.) is also found though very rarely. Two hairy caterpillars (*Amsacla albistriga,* W.) and *Pericallia ricini,* F. feed on leaves. Some mealy bugs.Occasionally attacked single plants severely.

(2)Jassids and aphids:

Observations taken at the Institute on jassid nymph population and the weather conditions showed that the humid and warm weather with little or no rain favour their multiplication. For aphids cloudy weather with drizzles or even fairly heavy rains was favourable. Only the American varieties suffered from jassid attack but the Desi types were slightly affected in bad years. The leaf curled and the edges dried up due to their attack and if the attack came early the whole crop would wither. Aphis were generally kept in check by the Lady-bird beetle and the predators.

Aphis gossypii

1) Alate, viviparous female 2) Wingless, viviparous female 3) Winged female, Summer form 4) Summer form of a wingless, viviparous female 5) Young nymph 6) and 6a) Infestations on plants 7) Formation of honeydew and sooty mould

Fig. 16.

(g) Plant Pathology

The Plant Pathology Section of the Institute of Plant Industry, Indore, was established in June, 1946. Staff of the section consisted of the Plant Pathologist and a Fieldman.

(1) Study of wilt resistance in cotton strains

Study of wilt diseases of cotton was started at the Institute in 1932 at the request of the Indian Central Cotton Committee. The disease became serious in 1936 and in 1938-39, 50% of breeding material was lost as a result of this disease.

By intensive breeding and selection a highly wilt resistant variety, called Family 2, was evolved in 1942. It was called Dhar 43 and later on it was re-named as Bhoj.

Systematic testing of the cotton strains for wilt resistance was started in 1946 with the establishment of the Plant Pathology Section and considerable number of varieties and hybrids have been tested.In 1946-47 twenty four strains of cotton were tested for wilt resistance, out of which 10 showed a high degree of resistance.

Study of wilt resistance in linseed strains:

In 1946-47, 25 linseed varieties from the various Central India States were tested for wilt resistance in small pots containing diseased soil. All of them were found to be susceptible.

(2) Physiologic specialiezation in *Fusarium oxysporum* f. lini.-Wilt disease of linseed:

Broadfoot, Borlaug and others found that the fusarium causing wilt of flax in composed of large number of pathogenic and cultural races. Similar studies were undertaken to observe the variations in the Fusarium causing wilt of linseed in Madhya Bharat. A number of isolations showed that the Fusarium varied appreciably in cultural characters and the isolates could be classified into six groups on this basis. An experiment was conducted in pots to study the pathogenecity of representative isolates from each group to five varieties of linseed. The results clearly indicated that the isolates vary in their pathogenecity to these five linseed varieties indicating thereby that there is physiologic specialization in the *Fusarium* causing wilt disease of linseed in Madhya Bharat.

(h) Chemistry and Soil

(1) Nitrogen balance in black cotton soils

Wad and Panse (1933) worked on black cotton soils for nitrogen balance. On basis of this study, they concluded that :

(i) Higher yields of cotton from dressings of safflower cake been shown tobe due, not so much to improvement in soil tilth, but have to appropriate supply of nitrogen.

(ii) A suitable method of studying nitrification in soil has been described.

(iii) In black cotton soil, the concentration of free nitrates has been found to be very low under the conditions of the experiment.

(iv) Algae have been shown to be an important factor in conservation of nitrates.

(v) The possibilities of the absence of appreciable leaching and dentrification in arable soils have been discussed.

(2) Erosion in black cotton soil

Wad and Tambe (1933) studied on erosion in black cotton soil, they observed that :

(i) Rapid erosion of the drains, grass, border and cultivated soil by monsoon showers has occurred in the field of the Institute of Indore.

(ii) Low gradient and protection by grass has failed to prevent it.

(iii) Rat holes, dry weather cracks, the sudden downpours and the nature of the soil are the agents of erosion.

(3) Effect of humus supply to soils

Jackson, Wad and Panse (1934) studied the effect of humus supply to soils. The authors found out that the permeability of black cotton soils is nearly double when dressed with compost; an important factor in reducing erosion. Losses of nitrogen are reduced. A steady supply of nitrified nitrogen is assured, both on clayey soils and sandy soils.

(4) Effects of fire heating of soils

Sreenivasan (1941) worked on the effects of fire heating of soils. He has found out that the main effects of fire heating of black cotton soil in crop growth to be due to an improvement in the physical properties of the soil. The colloidality of the soil is greatly reduced by firing as there is a corresponding increase in the coarse fractions. There is also an indication that fired soil can be successfully used to control the rise of sub-soil water. The remarkable similarity in the properties of fired and grey soils can be perhaps understood better when it is realised that grey soils are only transformations of black soil formed either in low lying areas adjoining black soil or after continuous heavy manuring and irrigation. Application of fired or grey soil to improve yielding capacity of black cotton soil can be carried out economically in a variety of ways. It can be filled in trenches alongside alternate rows of cotton, at the bottom of furrows, in ridge and in bores made by an earth auger.

(5) Effect of addition of loose soil

Sreenivasan (1941) working on the effect of addition of loose soil from the same field to well-drained and poorly drained soils has found out that the yield of cotton increased in both the cases, but while in the well-drained

field best result is obtained with the addition of a 2 inch layer of surface soil, the poorly drained field shown in general increasing differences in yields with increased addition of surface soil, a 5 inch layer giving the maximum yield.

Addition of surface soil from the rich field also increased the yield significantly in both the fields, the response being better with the greater thickness. But considering the cost of importation, this is not likely to be more profitable as compared to addition of soil from the same field.

(6) Function of soil cracks

Sreenivasan (1942) working on soil cracks during summer fallow suggests that the development of soil cracks during summer fallow must be promoted. This can be done by either avoiding or at any rate reducing to a minimum cultivation during summer fallow and by allowing crop plants to remain in the fields for a certain period after harvesting operations are over.

The advantages of cracking during any one season will be small, but the cumulative effect over prolonged period will be appreciable enough to increase the fertility of a field. Besides in a waterlogged field, the development of these cracks followed by the ingress of the surface soil through them will improve the permeability and drainage conditions in the field.

(7) Effect of crumb structure on soil fertility

Tamhame and Sreenivasan (1943) studied the effect of crumb structure on soil fertility and concluded that soil conservation depends essentially on the amount, kind and stability of the soil aggregates and the problem of improvement of eroded land for successful crop-growth, resolves into one of restoring structure. For black cotton soil, an economic way of achieving this will be keeping the sub-surface soil in a poor field open by dressings of lightly fired soil, not only increased yields are obtained without manuring but response to manures is also greater on soils so treated.

(8) Methods for reducing the alkaline content of the soil

In 1945, an experiment was laid out at Badnawar (a village in former Dhar State, about 60 miles from Indore) to see if there was any method for reducing the alkaline content of the soil. The soil before the start of the experiment contained as much as 2.8% of total soluble salts. The field was flooded after providing cross sub-drains. These were also manured with Ammonium Sulphate or F. Y. M. or groundnut cake. After two years of experiments, it was found that the plot provided with cross sub-drains removed most of the alkali. The alkaline content of the field was found to be 0.1% which was below the toxic limit.

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Appendix-I. **List of Principal Officers of the Department of Agriculture, GwaliorGovernment.**

Name	**Designation**	**Year**
Mr. Sam Higginbottom	Director of Agriculture, Gwalior Government.	1916-17
Mr. Don W. Griffin	Agricultural Engineer, Gwalior Government.	1916-17
Mr. Sam Higginbottom	Director of Agriculture, Gwalior Government.	1917-18
Mr. Don W. Griffin	Agricultural Engineer, Gwalior Government.	1917-18
Mr. L.A. Kenoyer	Economic Botanist, Gwalior Government.	1917-18
Mr. Sam Higginbottom	Director of Agriculture, Gwalior Government.	1918-19
Mr. Don W. Griffin	Agricultural Engineer, Gwalior Government.	1918-19
Mr. L.A. Kenoyer	Economic Botanist, Gwalior Government.	1918-19
Dr. R.L. Pendleton	Assistant Director of Agriculture, Northern Circle, Gwalior Government.	1918-19
Mr. C.C. Wisner	Assistant Director of Agriculture, Southern Circle, Gwalior Government.	1918-19
Mr. Moses Ezekiel	First Assistant Economic Botanist, Gwalior Government.	1918-19
Mr. B.L. Suryavanshi	Manager, Central Farm, Gwalior.	1918-19
Dr. Robert L. Pendleton	Officiating Director Agriculture & Assistant Director, Northern Circle, Gwalior Government.	1919-20
Mr. C.C. Wisner	Assistant Director, Southern Circle.	1919-20
Mr. S.K. Roy	Assistant to the Director Agriculture	1919-20

Mr. B.L. Suryavanshi	Farm Manager, Central Farm, Gwalior	1919-20
Mr. John William	Farm Manager, Central Farm, Ujjain	1919-20
Mr. Robert L. Pendleton	Director of Agriculture, Gwalior Government.	1921-22
Mr. S.A. Khan	Assistant Director of Agriculture, Northern Circle, Gwalior.	1921-22
Mr. C.C. Wisner	Assistant Director of Agriculture, Southern Circle, Ujjain.	1921-22
Major D.M. Jall	Civil Veterinary Officer, Gwalior Government.	1921-22
Dr. R.L. Pendleton	Director of Agriculture, Gwalior Government.	1922-23
Mr. G.K. Leley	Offg. Deputy Director of Agriculture, Prant-Gwalior.	1922-23
Mr. Ganesh Dutta	Deputy Director of Agriculture, Prant-Malwa, Ujjain	1922-23
Mr. G. K. Leley	Senior Assistant, Agricultural Research Laboratory, Gwalior	1922-23
Mr. K. L. Sanghi	Manager, Central Experimental Farm, Gwalior	1922-23
Mr. J. William	Manager, Central Experimental Farm, Ujjain	1922-23
Dr. R.L. Pendleton	Director of Agriculture, Gwalior Government.	1923-24
Captain Rao Bahadur Bapurao Powar	Member for Agriculture, Gwalior Government	1923-24
Mr. S. S. A. Khan	Deputy Agriculture, Prant-Gwalior & Isagarh.	1923-24
Mr. H. H. Pandya	Deputy Agriculture, Prant-Malwa, Ujjian	1923-24
Mr. G. K. Leley	Senior Assistant, Agricultural Research Laboratory, Gwalior	1923-24

Major D.M. Jall	Deputy Agriculture, I/C. C.V.D., Gwalior Government.	1923-24
Mr. Tatyaji Rao Yadav	Deputy Colonization Officer, Gwalior Government.	1923-24
Mr. Madho Rao Chohan	Behad Reclamation officer, Gwalior Government	1923-24
Mr. G.D. Shastree	Deputy Propaganda Officer, Agriculture Department, Gwalior Government.	1923-24
Mr. John Newby	Agricultural Engineer, Department of Agriculture, Gwalior Government.	1923-24
Mr. H.H. Pandya	Administrative Officer, Gwalior Government.	1925-26
Mr. R.R. Dongrey	Deputy Agriculture, Gwalior Division, Gwalior.	1925-26
Major D.M. Jall	Civil Veterinary, Officer Gwalior Government.	1925-26
Mr. Bodh Raj Sobti	Chief Chemist, Scindia Chemical Laboratory.	1925-26
Mr. H. H. Pandya	Administrative officer, Department of Agriculture & Agricultural Engineering, Gwalior Government	1926-27
Mr. G.K. Leley	Deputy Agriculture, Prant-Malwa, Ujjian	1926-27
Mr. R.R. Dongrey	Deputy Agriculture, Prant-Gwalior & Isagarh.	1926-27
Mr. K. N. Powar	Agriculture Chemist, Agriculture Research Laboratory, Gwalior	1926-27
Mr. G. H. Dixit	Crop Botanist, Gwalior Division, Gwalior	1926-27
Mr. L. V. Ghate	Crop Botanist, Malwa Division, Ujjain	1926-27

Mr. Bodhraj Sobti	Chief Chemist, Scindia Chemical Laboratory, Gwalior	1926-27
Mr. M. S. Paranjpe	Deputy for Agricultural Engineering, Gwalior Government	1926-27
Mr. Y.K. Mokashi	Assistant Engineer Boring, Gwalior Government	1926-27
Major D.M. Jall	Deputy Agriculture, I/C. Civil Veterinary Section	1926-27
Mr. H.H. Pandya	Administrative Officer, Gwalior Government.	1927-28
Mr. R.R. Dongrey	Deputy Agriculture, Prant-Gwalior & Isagarh.	1927-28
Mr. Kundan Lal Sanghi	Manager, Central Farm, Gwalior.	1927-28
Mr. G.K. Leley	Deputy Agriculture, Prant-Malwa.	1927-28
Mr. John William	Manager, Central Farm, Ujjain.	1927-28
Mr. K.N. Pawar	Chemist, Agricultural Research Laboratory, Gwalior.	1927-28
Mr. L.V. Ghate	Crop Botanist, Malwa Division.	1927-28
Mr. G.H. Dixit	Crop Botanist, Gwalior Division.	1927-28
Mr. Y.K. Mokashi	Assistant Engineer, Boring.	1927-28
Major D.M. Jall	Dy. I/C Civil Veterinary Section.	1927-28
Mr. Bodh Raj Sobti	Chief Chemist, Scindia Chemical Laboratory, Gwalior.	1927-28
Mr. H.H. Pandya	Administrative Officer, Department of Agricultural Engineering, Gwalior.	1928-29
Mr. R.R. Dongrey	Deputy Agriculture, Gwalior Division.	1928-29
Mr. G.K. Leley	Deputy Agriculture, Malwa Division.	1928-29
Mr. G.H. Dixit	Crop Botanist, Gwalior Division.	1928-29
Mr. L.N. Mathur	Crop Botanist, Malwa Division.	1928-29

Mr. P.D. Tambat	Assistant Engineer, Boring.	1928-29
Mr. S.K. Roy	Manager, Dairy & Bull Breeding Farm, Maharjpur.	1928-29
Mr. H.H. Pandya	Administrative Officer Department of Agriculture & Agricultural Engineering.	1930-31
Major L.M. Thosar	Civil Veterinary Officer, Gwalior Government.	1930-31
Mr. R.R. Dongray	Deputy Administrative Officer, Agricultural Section, Gwalior Division, Gwalior.	1930-31
Mr. G.K. Leley	Deputy Administrative Officer, Agricultural Section. Malwa Division, Ujjain.	1930-31
Mr. G.K. Dixit	Crop Botanist, Gwalior Division.	1930-31
Mr. S. K. Roy	Manager, Dairy & Bull Breeding Farm, Maharjpur.	1930-31
Mr. P.D. Tambat	Agricultural Engineer, Gwalior Government.	1930-31
Mr. Bodh Raj Sobti	First Chemist, Chemical & Botanical Laboratory, Gwalior.	1930-31
Mr. L.M. Mathur	Crop Botanist, Malwa Division, Ujjain.	1930-31
Mr. H.H. Pandya	Agricultural Advisor, Gwalior Government.	1931-32
Mr. R.R. Dongrey	Deputy Agriculture, Gwalior Division, Gwalior.	1931-32
Mr. G.K. Leley	Deputy Agriculture, Malwa Division, Ujjain.	1931-32
Mr. G.H. Dixit	Crop Botanist, Gwalior Division. Gwalior.	1931-32
Mr. L.M. Mathur	Crop Botanist, Malwa Division, Ujjain.	1931-32
Mr. S.K. Roy	Manager, Dairy & Bull Breeding Farm, Maharajpur.	1931-32

Mr. Bodh Raj Sobti	First Chemist, Chemical & Botanical Laboratory.	1931-32
Mr. P. D. Tambat	Agricultural Engineer, Gwalior Government.	1931-32
Bapu Rao Pawar, Major, Rao Bahadur	Member for Agriculture, Gwalior Government.	1932-33
Mr. H.H. Pandya	Director of Agriculture, Gwalior Govt.	1933-34
Mr. R.R. Dongrey	Dy. Director of Agriculture, Gwalior Division, Gwalior.	1933-34
Mr. G.K. Leley	Dy. Director of Agriculture, Malwa Division, Ujjain.	1933-34
Mr. G.H.Dixit	Crop Botanist, Gwalior Division, Gwalior.	1933-34
Mr. L.M. Mathur	Crop Botanist, Malwa Division, Ujjain.	1933-34
Major L.M. Thosar	Civil Veterinary Officer, Gwalior Government.	1933-34
Mr. P.D. Tambat	Agricultural Engineer, Gwalior Government.	1933-34
Mr. S.K. Roy	Manager, Dairy and Bull Breeding Farm, Maharajpur.	1933-34
Mr. H. Pandya	Director of Agriculture, Gwalior Government.	1934-35
Mr. R.R. Dongrey	Dy. Director of Agriculture, Gwalior Division, Gwalior.	1934-35
Mr. G.K. Leley	Dy. Director of Agriculture, Malwa Division, Ujjain.	1934-35
Mr. P.D. Tambat	Agricultural Engineer, Agriculture Engg. Section, Lashkar.	1934-35
Major L.M. Thosar	Civil Veterinary Officer, Civil Veterinary Section, Lashkar.	1934-35
Mr. S.K. Roy	Manager, Dairy and Bull Breeding Farm, Maharajpur.	1934-35

Mr. H.H. Pandya	Director of Agriculture, Gwalior Government.	1935-36
Mr. R.R. Dongrey	Deputy Director of Agriculture, Prant-Gwalior.	1935-36
Mr. P.D. Tambat	Agriculture Engineer, Gwalior Government.	1935-36
Mr. H.H. Pandya	Director of Agriculture, Gwalior Government.	1936-37
Lt. Sardar D.K. Jadhav	Director of Agriculture, Gwalior Government.	1936-37
Mr. N.S. Apte	Director of Agriculture, Gwalior Government.	1936-37
Mr. R.R. Dongrey	Dy. Director of Agriculture, Gwalior Division, Gwalior.	1936-37
Lt. Sardar D.K. Jadhav	Director of Agriculture, Gwalior Govt.	1936-37
Lt. Sardar D.K. Jadhav	Director of Agriculture, Gwalior Government.	1937-38
Mr. L.M. Thosar	Civil Veterinary Officer, Gwalior Government.	1937-38
Mr. G.K. Leley	Deputy Director of Agriculture, Malwa Division, Ujjain.	1937-38
Mr. L.N. Mathur	Crop Botanist, Malwa Division, Ujjain	1937-38
Mr. Y.K. Mokashi	Agriculture Engineering & I/C, Boring Section.	1937-38
Mr. N.S. Apte	Assistant to the Director of Agriculture, Gwalior Government.	1938-39
Mr. A.C. Tandan	Manager, Central Farm, Gwalior.	1938-39
Mr. Bodh Raj Sobti	Chief Chemist, Chemical Section, Gwalior Government.	1938-39
Mr. Kundan lal Sanghi	Manager, Central Farm, Ujjain.	1938-39
Mr. G.H. Dixit	Crop Botanist, Gwalior Division, Gwalior.	1938-39

Mr. S.V. Gokhale	I/C Manager, Dairy and Bull Breeding Farm, Maharajpur.	1938-39
Lt. Sardar D.K. Jadhav	Director of Agriculture, Gwalior Government.	1939-40
Mr. G.K. Lele	Deputy Director of Agriculture, Malwa Division, Ujjain.	1939-40
Mr. S.V. Samarth	Assistant to the Director of Agriculture, Gwalior Government.	1939-40
Mr. G.S. Kulkarni	Mycologist, Gwalior Government.	1939-40
Mr. C.B.L. Bhargava	Entomologist, Gwalior Government.	1939-40
Mr. L.N. Mathur	Crop Botanist, Gwalior Division, Gwalior.	1939-40
Mr. S.M. Wakankar	Crop Botanist, Malwa Division, Ujjain.	1939-40
Lt. Sardar D.K. Jadhav	Director of Agriculture, Gwalior Govt.	1940-41
Mr. S.V. Samarth	Offg. Director of Agriculture, Gwalior Government.	1940-41
Mr. G.K. Leley	Dy. Director of Agriculture, Malwa Division, Ujjain.	1940-41
Mr. Bodh Raj Sobti	Chief Chemist, Chemical & Botanical Laboratory, Gwalior.	1940-41
Mr. L.N. Mathur	Junior Botanist, Chemical & Botanical Laboratory, Gwalior.	1940-41
Mr. G.S. Kulkarni	Mycologist. Chemical & Botanical Laboratory, Gwalior.	1940-41
Mr. C.B.L. Bhargava	Entomologist. Chemical & Botanical Laboratory, Gwalior.	1940-41
Mr. G.H. Dixit	I/C Harsi Experimental Farm, Bagwai.	1940-41
Mr. Kundan lal Sanghi	Manager, Central Farm, Ujjain.	1940-41

Mr. N.M. Deshmukh	Director of Agriculture, Gwalior Government.	1944-45
Mr. K.N. Pawar	Chief Chemist, Gwalior Govt.	1944-45
Mr. N.S. Apte	Dy. Director of Agriculture, Malwa Division, Ujjain.	1944-45
Mr. C.B.L. Bhargava	Dy. Director of Agriculture, Gwalior Division, Gwalior.	1944-45
Mr. G.H. Dixit	Senior Botanist, Gwalior Government.	1944-45
Mr. G.S. Kulkarni	Mycologist, Gwalior Government.	1944-45
Dr. Ram Rakshpal	Entomologist, Gwalior Government.	1944-45

Appendix-II. **List of Publications**

Year	**Name of the Officer Contributing**	**Subject of Article**	**Issued as leaflet or published in,'*Jayaji Pratap'***
1917-18	Mr. Sam Higginbottom, Director of Agriculture, Gwalior Government.	Trenching of Manures.	Bulletin
1917-18	L.A. Kenoyer, Economic Botanist, Gwalior Government.	Seed Selection and Testing.	Bulletin
1917-18	L.A. Kenoyer, Economic Botanist, Gwalior Government.	Sanitations for Rural communities.	Bulletin
1917-18	Mrs. Kenoyer	House Decoration an Art.	Bulletin

1918-19	Mr. L.A. Kenoyer, Economic Botanist, Gwalior Government.	Improvement of a Village in India.	Bulletin
1918-19	Mr. L.A. Kenoyer, Economic Botanist, Gwalior Government.	Improvement of a Village in India. (Hindi)	Bulletin
1918-19	R.L. Pendleton, Assistant Director Agriculture, Gwalior Government.	Use of Agricultural library.	Bulletin
1918-19	Moses Ezekiel, First Assistant Economic Botanist, Gwalior Government.	Fodder in the Irrigated Area of the Gwalior State.	*Jayaji Pratap*
1918-19	Moses Ezekiel, First Assistant Economic Botanist, Gwalior Government.	Some Suggestions to Farmers in the Village of Gwalior State.	*Jayaji Pratap*
1918-19	L.A. Kenoyer, Economic Botanist, Gwalior Government.	Soil Tillage.	Bulletin
1919-20	Department of Agriculture & Agricultural Engineering	Some suggestions to their field crops.	*Jayaji Pratap*
1919-20	Department of Agriculture & Agricultural Engineering	Health Hints for the Rainy Season.	*Jayaji Pratap*
1921-22	Department of Agriculture & Agricultural Engineering	Time Factor in Agricultural Experiments (English & Hindi).	*Jayaji Pratap*

1921-22	Department of Agriculture & Agricultural Engineering	Note - Regarding Collection of Jowar in Central Experiment Farm, Gwalior (English)	*Jayaji Pratap*
1921-22	Department of Agriculture & Agricultural Engineering	Ammonium Sulphate (English)	*Jayaji Pratap*
1921-22	Department of Agriculture & Agricultural Engineering	Cultivation of Cambodia Cotton (Hindi)	*Jayaji Pratap*
1921-22	Department of Agriculture & Agricultural Engineering	Cultivation of Groundnut (Hindi)	*Jayaji Pratap*
1921-22	Department of Agriculture & Agricultural Engineering	Note on the Cultivation of Cambodia Cotton (English)	*Jayaji Pratap*
1922-23	Agriculture Research Laboratory, Gwalior	Soils (Hindi)	Bulletin
1922-23	Agriculture Research Laboratory, Gwalior	Manures (Hindi)	Bulletin
1922-23	Agriculture Research Laboratory, Gwalior	Seed- testing, Purity and Selection (Hindi)	Bulletin
1925-26	Department of Agriculture & Agricultural Engineering	Weed Manual	Bulletin
1925-26	Department of Agriculture & Agricultural Engineering	Barani Kapas	Bulletin

1926-27	Department of Agriculture & Agricultural Engineering	The selection and Testing of Seeds	Bulletin
1926-27	Department of Agriculture & Agricultural Engineering	A Sanitary and Profitable Method of Disposing of all Refuse from House, Garden, Kitchen, Stable, Cattle Shed, Latrine and Village.	Bulletin
1926-27	Department of Agriculture & Agricultural Engineering	Rural Sanitation	Bulletin
1926-27	Department of Agriculture & Agricultural Engineering	Ploughing	Bulletin
1926-27	Department of Agriculture & Agricultural Engineering	Culture of Pusa Wheats in Gwalior State.	Bulletin
1926-27	Department of Agriculture & Agricultural Engineering	Farm Accounts	Bulletin
1926-27	Department of Agriculture & Agricultural Engineering	The Groundnut Cultivation	Bulletin
1926-27	Department of Agriculture & Agricultural Engineering	Manure and Manuring	Bulletin
1926-27	Department of Agriculture & Agricultural Engineering	Selection, Testing and Preservation of Seeds	Bulletin

1926-27	Department of Agriculture & Agricultural Engineering	Soil and Soil-culture	Bulletin
1926-27	Department of Agriculture & Agricultural Engineering	Rules of the Gwalior Agriculture Exhibition	Bulletin
1926-27	Department of Agriculture & Agricultural Engineering	Weed Manual	Bulletin
1926-27	Department of Agriculture & Agricultural Engineering	Barani kapas	Bulletin
1926-27	Crop Botanist, Malwa Division	The Cultivation of Small Japan Groundnut in Malwa	*Jayaji Pratap*
1926-27	Crop Botanist, Malwa Division	The Cotton Problem in Gwalior State	*Jayaji Pratap*
1927-28	Department of Agriculture	The selection and testing of seeds.	Bulletin
1927-28	Department of Agriculture	A sanitary and profitable method of disposing of all refuse from house, garden, kitchen, stable, cattle shed, latrine and village.	Bulletin
1927-28	Department of Agriculture	Rural sanitation.	Bulletin
1927-28	Department of Agriculture	Ploughing.	Bulletin
1927-28	Department of Agriculture	Culture of Pusa Wheats in Gwalior State.	Bulletin

1927-28	Department of Agriculture	Farm accounts.	Bulletin
1927-28	Department of Agriculture	The Groundnut cultivation.	Bulletin
1927-28	Department of Agriculture	Manure and manuring.	Bulletin
1927-28	Department of Agriculture	Selection, testing and preservation of seeds (revised).	Bulletin
1927-28	Department of Agriculture	Soils and soil-culture.	Bulletin
1927-28	Department of Agriculture	Rules of the Gwalior Agricultural Exhibition.	Bulletin
1927-28	Department of Agriculture	Weed control.	Bulletin
1927-28	Department of Agriculture	Cultivation of Barani Kapas.	Bulletin
1927-28	Department of Agriculture	A short note on the cultivation of Cambodia cotton	*Jayaji Pratap*
1927-28	Department of Agriculture	A leaflet on the cultivation of poppy was published and distributed in Malwa.	Bulletin
1928-29	Department of Agriculture	The Cultivation of Cambodia Cotton	*Jayaji Pratap*
1928-29	Department of Agriculture	The Cultivation of Poppy	Leaflet
1931-32	Crop Botanist, Malwa	Preservation of Foods	*Jayaji Pratap*
1931-32	Crop Botanist, Malwa	Cultivators Sayings	*Jayaji Pratap*
1931-32	Deputy Agriculture, Malwa	Cambodia Cotton as a Dry Land Crop in Malwa	*Jayaji Pratap*

1932-33	Department of Agriculture	Mango and Mulberry Cultivation	Bulletin
1932-33	Department of Agriculture	Use of Kaoline against Rinderpest	Bulletin
1932-33	Department of Agriculture	Treatment of Anthrax	Bulletin
1932-33	Department of Agriculture	Grass Hopper	Bulletin
1933-34	Civil Veterinary Officer.	Stray Dogs and their Control	*Jayaji Pratap*
1933-34	Civil Veterinary Officer.	Foot and Mouth Disease and its Treatment	*Jayaji Pratap*
1933-34	Civil Veterinary Officer.	Foot and Mouth Disease and its Treatment	Pamphlet.
1933-34	Civil Veterinary Officer.	Benefit of Castration by Burdizo Method	Pamphlet.
1933-34	Manager Dairy.	Milk Problem in Gwalior	*Jayaji Pratap*
1933-34	Crop Botanist, Malwa.	Harmful Effects of Mixing Good Quality Cotton in Indian cottons	*Jayaji Pratap*
1933-34	Deputy Director of Agriculture, Malwa.	Destruction of Prickly Pears through Insects Agency	*Jayaji Pratap*
1933-34	Agricultural Inspector, Tawarghar.	Control of Grasshopper	*Jayaji Pratap*
1934-35	Crop Botanist, Malwa.	Pink boll worm of cotton	*Jayaji Pratap*
1934-35	Civil Veterinary Officer.	Benefits of castration by the Burdizzo's methods	Pamphlet

1934-35	Naib Tehsildar, Propaganda, Sabalgarh.	Merits of Co 205 variety of Sugarcane	*Jayaji Pratap*
1934-35	Naib Tehsildar, Propaganda, Sabalgarh.	Benefits of crushing Sugarcane by Sultan Mills	*Jayaji Pratap*
1935-36	Manager, Dairy	Milk Problem.	*Jayaji Pratap*
1935-36	Crop Botanist, Malwa	The pink bollworm of cotton and how to control it.	*Jayaji Pratap*
1935-36	Crop Botanist, Malwa	The marketing of Agricultural Produce.	*Jayaji Pratap*
1935-36	Naib Tehsildar, Mandsaur	Control of Rats.	*Jayaji Pratap*
1935-36	Naib Tehsildar, Mandsaur	Control of White ants.	*Jayaji Pratap*
1935-36	Naib Tehsildar	Bihar plough.	Leaflet
1935-36	Manmohan Swarup Bhatnagar	Report of the survey of sugarcane cultivation in the Gwalior State.	-
1937-38	Department of Agriculture	A Bulletin on Groundnut was published by the Department.	-
1938-39	Department of Agriculture	Utility of Rabi Duffan	*Jayaji Pratap*
1938-39	Naib Tehsildar, Propaganda, Mandsaur	Orange Plantation	*Jayaji Pratap*
1938-39	Naib Tehsildar, Propaganda, Mandsaur.	Tobacco Cultivation	*Jayaji Pratap*

Appendix-III. **Weeds prevalent in Gwalior region during the period 1918-1924.**

S.No.	Latin and English Names	Vernacular Names	Botanical Names
1	Abutilon	Petari, Kanghai	*Abutilon indicum*
2	Acacia	Babul,Kikar	*Acacia Arabica*
3	Acacia	Safed kikar, Arinj	*Acacia leucophloea*
4	Acalypha	Kupi	*Acalypha indica*
5	Achyranthes	Adhajharu, Aghada,Chirchita	*Achyranthes aspera*
6	Aerua	Pandhra feda	*Aerua lanat*
7	Ageratum		*Ageratum conzyoides*
8	Alhagi	Gewancha,Jawasa	*Alhagi camelorum*
9	Alternanthera	Ghardughi,Gatighasi	*Alternanthera sessilis*
10	Alysicarpus	Shevra	*Alysicarpus monilifer*
11	Alysicarpus		*Alysicarpus rugasus*
12	Amaranthus	Spiny Amaranth,Katari,Kan the math	*Amaranthus spinosus*
13	Amaranthus	Green Amaranath	*Amaranthus viridis*
14	Amaranthus		*Amaranthus polygamus*
15	Ammania	Dhan Bhaji	*Ammania baccifera*
16	Anagallis	Poor man's weather-glass	*Anagallis arvensis*
17	Andropogon	Spear grass,Lap,Parch	*Andropogon contortus*
18	Andropogon	Rukah,Palwa	*Andropogon pertusus*
19	Andropogon		*Andropogon nardus*

20	Andropogon	Khas-khas	*Andropogon squarrosus*
21	Anthistiria	Chudur jahara	*Anthistiria ciliata*
22	Apluda	Gandhi	*Apluda varia*
23	Argemone	Prickly poppy,Kateli	*Argemone mexicana*
24	Aristida	Sinka	*Aristida adscenscionis*
25	Asphodelus	Bakat-piazi	*Asphodelus tenuifolius*
26	Asteracantha	Talimkhana	*Asteracantha longifolia*
27	Balanites	Hingan,Hingot	*Balanites aegyptica*
28	Blumea		*Blumea wightiana*
29	Blumea		*Blumea lacera*
30	Blumea		*Blumea laciniata*
31	Boerhaavia	Santh,Ghetuli,Kapark uti	*Boerhaavia diffusa*
32	Butea	Dhak,Palas	*Butea frondosa*
33	Caesulia		*Caesulia axillaris*
34	Calotropis	Ak,Madar	*Calotropis procera*
35	Capparis	Karil	*Capparis aphylla*
36	Capparis		*Cappris sepiaria*
37	Carissa	Karaunda	*Carissa spinarum*
38	Cassia	Panwar	*Cassia obtusifolia*
39	Celosia	Safed murgi ka phul,Kukuda	*Celosia argentea*
40	Celsia	Kutki	*Celsia coromandeliana*
41	Chenopodium	White goose foot, Bathua, Lamsquarter, Childhan	*Chenopodium album*
42	Cichorium	Chicory, Kasni	*Chichorium intybus*

43	Chloris		*Chlris barbata*
44	Chrozophora	Bothri	*Chrozophora rottleri*
45	Chrozophora		*Chrozophora prostrata*
46	Cleome	Hulhul	*Cleome viscose*
47	Clerodendron	Urui	*Clerodendron phlomoides*
48	Cocculus	Hier, Kari, Karsan	*Cocculus villosus*
49	Commelina	Day-flower,Kaena	*Commelina benghalensis*
50	Convolvulus	Field Bindweed,Chandvel	*Convolvulus arvensis*
51	Convolvulus	Chois	*Convolvulus pleuricanlis*
52	Corchoris		*Corchoris tridens*
53	Corchoris	Cheeh Bhaji	*Corchoris acutangulis*
54	Corchoris	Rajan	*Corchoris trilocurlari*
55	Corchoris	Chichari	*Corchoris fascicularis*
56	Crotalaria	Aulabi	*Crotalaria medicaginea*
57	Crotalaria	Sunn	*Crotalaria orixensis*
58	Cuscuta	Akal-bel,Amar-bel	*Cuscuta reflexa*
59	Cynodon	Dub,Bermuda Grass	*Cynodon dactylon*
60	Cyperus	Motha	*Cyperus rotundus*
61	Datura	Kala Dhatura	*Datura fastuosa*
62	Digrera	Kunjru,Tandurka	*Digera arvensis*
63	Dinebra	Lona	*Dinebra arabica*
64	Echinops	Globe thistle,Gokru	*Echinops echinatus*
65	Eclipta	Maka guma	*Eclipta erecta*

66	Eleusine	Jhingri	*Eleusine indica*
67	Eleusine	Makra	*Eleusive aegyptica*
68	Eragrostis	Kusa,Dab	*Eragrostis cynosuroides*
69	Eragrostis		*Eragrostis minor*
70	Eragrostis	Lamcha,Godila	*Eragrostis interrupta*
71	Eragrostis	Chiriya ka dana	*Eragrostis pilosa*
72	Eragrostis	Bharbhuri,Mondia	*Eragrostis tenella*
73	Eriochloa		*Eriochloa polystachya*
74	Euphorbia	Titli	*Euphorbia dracunculoides*
75	Euphorbia	Dudhi	*Euphorbia hirta*
76	Euphorbia	Dudhi	*Euphorbia thymifolia*
77	Euphorbia	Dudhi	*Euphorbia hypericifolia*
78	Fagonia	Jawasa	*Fagonia cretica*
79	Flaveria		*Flaveria contrayerba*
80	Fumaria	Fumitory	*Fumaria parviflora*
81	Gnaphalium		*Guaphalium leteo-album*
82	Gnaphalium		*Gnaphalium indicum*
83	Gnaphalium		*Gnaphalium purpureum*
84	Goniocaulon	Kadu	*Goniocaulorn glabrum*
85	Grangea	Godri	*Grangea madera spatana*
86	Gynandropsis	Hulhul	*Gynandropsis pentaphylla*
87	Heliotropium		*Heliotropium strigosum*
88	Indigofera	Bekaria,Torki	*Indigofera linifolia*
89	Indigofera	Vekriavas	*Indigofera cordifolia*

90	Indigofera	Barbuda	*Indigofera glandulosa*
91	Indigofera		*Indigofera oblongifolia*
92	indigofera	Bhuinguli	*Indigofera enneaphylla*
93	Inula	Sonkadi	*Inula india*
94	Ipomoea		*Ipomoea obscura*
95	Ipomoea	Tiger-foot,Morning Glory Belukaja	*Impomoea pes-tigridis*
96	Ischaemum		*Ischaemum hirtum*
97	Justicia		*Justicia diffusa*
98	Justicia		*Justicia simplex*
99	Lagascea	Karujira,laljira	*Lagascea mollis*
100	Laggera	Kukroundha	*Laggera aurita*
101	Lathyrus		*Lathyrus aphaca*
102	Launea	Jangli Gobi	*Launea asplenifolia*
103	Leucas	Kumbha	*Leucas urticaefolia*
104	Leucas	Kumbha	*Leucas aspera*
105	Leucas	Dhurpi sag	*Leucas cephalotes*
106	Linaria	Toad-flax	*Linaria ramosissima*
107	Lindenbergia		*Lindenbergia urticacfolia*
108	Lippia	Jal pimpri	*Lippia nodiflora*
109	Melia	Neem,Margosa	*Melia azadirachta*
110	Melilotus	Senji,Metha	*Melilotus indica*
111	Melilotus		*Melilotus alba*
112	Merremia	Durkuni	*Merremia emarginata*
113	Mimosa	Chilati	*Mimosa hamata*

114	Mollugo		*Mollugo hirta*
115	Nothosaerua		*Nothosaerua brachiata*
116	Ocimum	Hoary Tulsi, Ram Tulsi,Bharbari	*Ocimum canum*
117	Ocimum	Tulsi	*Ocimum sanctum*
118	Oldenlandia		*Oldenlandia dichotoma*
119	Ophiurus	Sonthe	*Ophiurus corymbosus*
120	Orobanche		*Orobanche aegyptica*
121	Oxalis	Sorrel,Amrul,Chalmari	*Oxalis corniculata*
122	Panicum	Barnyard Grass,Sanwak	*Panicum crus-galli*
123	Panicum		*Panicum isachne*
124	Panicum		*Panicum javanicum*
125	Panicum		*Panicum ramosum*
126	Panicum	Kutki	*Panicum psilipodium*
127	Paspalum	Crab Grass,Takri	*Paspalum sanguinale*
128	Pennisetum	Anjan,Dhaman	*Pennisetum cenchroides*
129	Peristrophe		*Peristrophe bicalyculata*
130	Phoenix	Wild date,Kajur,Shindi	*Phoenix sylvestris*
131	Phyllanthus	Hazarmani,Ranavali	*Phyllanthus maderaspatanus*
132	Phyllanthus	Jar-Amla,Jangli Amli	*Phyllanthus niruri*
133	Physalis	Ban-tipariya	*Physalis minima*
134	Physalis	Tipari,Cape gooseberry	*Physalis peruviana*
135	Plantago		*Plantgo amplexicaulis*

136	Pluchea	Banserai,Cholikalia,Sarahi	*Pluchea lanceolata*
137	Polycarpaea		*Polycarpaea corymbosa*
138	Polygala	Phulani	*Polygala chinensis*
139	Polygonum		*Polygonum plebeium*
140	Portulaca	Purslain,Kulfa,Lunak,Noninya,Ghor	*Portulaca oleracea*
141	Porulaca	Chuili bhaji	*Portulaca quadrifida*
142	Potentilla	Cinquefoil	*Potentilla supine*
143	Pulicaria		*Pulicaria foliolosa*
144	Pulicaria		*Puliciaria crispa*
145	Pupalia		*Pupalia lappacea*
146	Ranunculus	Accursed Crowfoot	*Ranunculus sceleratus*
147	Rhynchosia	Turel	*Rhynchosia minima*
148	Rumex	Doek	*Rumex dentatus*
149	Saccharum	Kans	*Saccharum spontaneum*
150	Saccharum	Sarpat,Munj	*Saccharum arundinaceum*
151	Salvia		*Salvia plebeian*
152	Saponaria	Soapwort,Sabani	*Saponaria vaccaria*
153	Sesbania	Jayanti,Dhaincha	*Sesbania aculeate*
154	Setaria	Chiriya Chaina,Sawa	*Setaria intermedia*
155	Setaria	Foxtail Grass,Bandra	*Setaria glauca*
156	Sida	Karenti,Chikna	*Sida spinosa*
157	Solanum	Black Nightshade	*Solanum nigrum*
158	Solanum	Kateli	*Solanim xanthocarpum*
159	Sonchus	Sow Thistle	*Sonchus arvensis*

160	spermacoce	Gathani	*Spermacoce hispida*
161	Sphaeranthus	Godri	*Sphaeranthus indicus*
162	Spergula	Corn Spurrey	*Spergula arvensis*
163	Striga		*Striga lutea*
164	Sutera		*Sutera glandulosa*
165	Tephrosia	Sarphanki	*Tephrosia purpurea*
166	Trianthema	Biskopra,Kaparkuti	*Trianthema monogyna*
167	Trianthema		*Trianthema pentandra*
168	Tribulus	Gukru	*Tribulus terrestris*
169	Trichodesma		*Trichodesma indicum*
170	Tridax		*Tridax procumbens*
171	Triumfetta	Menduli	*Triumfetta rotundifolia*
172	Vernonia	Kala Jira	*Vernonia cinerea*
173	Vernonica	Speedwell	*Vernonica anagallis*
174	Volutarella	Brahmadandi	*Volutarella divaricata*
175	Withania	Askand,Asind	*Withania somnifera*
176	Xanthium	Cocklebur,Chhota Dhatura,Ardhasis	*Xanthium strumarium*
177	Zizyphus	Ber	*Zizyphus jujube*
178	Zizyphus	Ber,Jharberi	*Zizyphus rotundifolia*
179	Zizyphus	Makai,Makoh,Bamolan	*Zizyphus oenoplia*

(Kenoyer, 1924)

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