Scientific Reports of the Imperial Institute of Agricultural Research, Pusa.

(Including the Reports of the Imperial Dairy Expert, Physiological Chemist and Sugarcane Expert)

1934-35

REPORT OF THE DIRECTOR

[F. J. F. SHAW, D. Sc., (LOND.), A.R.C.S., F.L.S., I.A.S. AND RAO BAHADUR B. VISWA NATH, F.I.C.]

I. GENERAL.

Transfer of the Imperial Institute of Agricultural Research from Pusa to Delhi.—During the year under review, the decision to move the Imperial Institute of Agricultural Research from Pusa to Delhi was taken. This was necessitated by the destruction of the Phipps laboratory and many other buildings at Pusa in the great earthquake of the 15th January 1934.

The site which was finally selected for locating the new Institute lies about three and a half miles to the west of the Viceroy's House, New Delhi. Part of the land is within the limits of the Imperial capital area and a part belongs to the villages of Shadipur, Todapur and Naraina. The new site contains about 476 acres of good agricultural land and about 300 acres of pasture and land for buildings. The area of agricultural land available at the new site being very much smaller than that at Pusa, the farm at Karnal—about seventy miles by rail and good road from Delhi—will form a substation of the Imperial Institute of Agricultural Research at Delhi.

The Director of the Institute and a part of his staff were transferred to Delhi in November 1934 and the Director's office has been temporarily located in the Old Secretariat buildings. Steps were immediately taken, in collaboration with the local officials, for the acquisition of such land at the site as was not already Government property and plans and estimates for the lay out of the estate and

for the construction of residential and non-residential buildings were prepared in consultation with the Central Public Works Department.

Progress with the project has been very rapid. By February 1935 the necessary approach roads were made. His Excellency the Viceroy and the Countess of Willingdon laid the foundation of the Library on the 19th February 1935. Farm buildings and quarters for the advance party for agricultural lay out were completed by May 1935. The agricultural staff, with implements, bullocks and steam ploughing tackle arrived at the site in May 1935 and commenced the difficult and arduous task of levelling and laying out the agricultural and botanical areas.

By the end of July 1935 the Farm buildings and most of the residential buildings were in an advanced stage of construction and a commencement was made on the library and the laboratories. The preliminaries relating to the supply of electricity, filtered and unfiltered water and the disposal of sewage and drainage were settled by September and the preparation of necessary plans and estimates for these items was commenced. It is expected that the construction of buildings will be completed by April 1936 and that the necessary fittings and equipment will be installed by September 1936. The actual transfer of staff and stores and live-stock from Pusa will, it is hoped, be completed by September 1936.

II. RESEARCH AND INVESTIGATIONS

Soils and Fertilisers

In view of the decision to shift the Institute from Pusa to Delhi next year, research work in all the Sections, except that of the Botanical Section which retains a Substation at Pusa, was confined to the completion of the work on hand or to bringing it to a stage at which it could be kept in abeyance. In the Agricultural Section the cropping scheme for *rabi* (winter) was materially altered by cutting down the area for seed multiplication and providing land to grow sugarcane as a revenue crop.

A series of experiments carried out with different soils and different nitrogenous materials has not afforded any evidence to confirm the recent claims by the workers of the Allahabad University that sunlight is largely, if not entirely, responsible for bringing about nitrification in the soil. Mr. Joshi and his co-worker have, on the other hand, found that direct exposure of soil to strong sunlight inhibits nitrification and reduces nitrates.

The estimation of nitrogen-fixing and carbondioxide evolution capacities of soils collected in different seasons from plots receiving differential manurial treatments has not revealed consistent and marked differences due to treatment or season.

In previous years it was stated from laboratory experiments that the yield of wheat after applying sann-hemp tops alone was equal to that when the whole of the sann-hemp plant was buried in the soil, and that the cultivator would get additional revenue of fibre from the stems. This has been confirmed in a field trial: the yield of fibre from the stems remaining after using tops as manure was 500 to 600 lb. per acre. The economics of the problem will be fully discussed in a report which will soon be ready for publication.

With a view to ascertain the possibilities of making the insoluble phosphate in the apatite called Khudada phosphate available to crops, two composts were prepared, *viz.* (1) apatite 100 lb.+ sand 100 lb.+sulphur 25 lb.+ charcoal 16 lb. + water 25 lb. (2) apatite 100 lb. + green berseem (clover) 100 lb. + sulphur 25 lb. The matured composts were tested on the field scale along with the raw phosphate in a finely ground form, and the yields of mustard obtained did not show that the preparation of either compost was worth while.

In experiments designed to elucidate the lime requirements of acid soils maximum crop yield was obtained from plots limed to pH 7 and the yields decreased with increasing applications of lime, except in the case of barley plants which yielded the maximum when liming was done at twice the amount required to bring the soil reaction to pH 7.

A study on dew as a factor in the moisture economy of the soil, and the contribution made to the growth of *rabi* (winter) crops was carried out both in the laboratory and in the pot-culture house, with tobacco seedlings which were neither exposed to rain nor were watered. Dew was the only source of moisture, and the seedlings lived throughout the season, passing through the usual vegetative and reproductive phases. Determination of moisture in soil at different times of the day indicated that, besides supplying three to four per cent of moisture in the surface layers, dew deposition takes place even in the lower layers of the soil down to a depth of one foot. It would appear that evaporation and absorption phases operate in the soil to an extent that the balance is enough to sustain the normal functions of the plant. At or about the hygroscopic stage, the soil loses appreciable amounts of water during day but during night more moisture is gained both by direct absorption and condensation in the interior of the soil. This increases with the depth of tillage.

Sann-hemp (*Crotalaria juncea*), cow pea (*Vigna catjang*), *mung* (*Phaseolus radiatus*), sweet-pea (*Lathyrus odoratus*) and *kerao* (*Pisum arvense*) are under investigation to ascertain (1) whether bacteriophage occurs in all legumes and legume nodules, (2) if it occurs, whether it is the same or different in different types of

nodules, (3) if different, whether they form the basis for the classification of nodule bacteria, and (4) the relationship of the bacteriophage to the formation or otherwise of nodules. It is also being ascertained whether different forms of Azotobacter exist in soils, and, if so, whether they fix nitrogen in an equal or varying degree as compared to the large globule or oval forms of Azotobacter in Ashby's mannite solution.

Among other investigations bearing on the maintenance or improvement of the fertility of soils may be mentioned those intended to elucidate the optimum requirements of calcareous soils, as typified by the Pusa soil containing about 40 per cent of calcium carbonate, in nitrogenous, phosphatic and potassic fertilizers, the availability of superphosphate in relation to depth of placement, and the relationship between citric acid solubility of a phosphatic fertilizer and crop response.

CROPS

Wheat.—Large-scale tests with *Pusa 165* (*Federation X Pusa 4*) and *Pusa 120* (*Federation X Pusa 52*), in comparison with the standard Pusa and Punjab types, made simultaneously at Pusa, at Karnal, and at several farms in the Punjab and the United Provinces under various climatic and other conditions including canal-irrigated, well-irrigated and rain-fed lands, have established the outstanding success of *Pusa 165* which occupied the first three places 14 times out of 18 trials. In the United Provinces and the Eastern Punjab to which it appears to be particularly well suited *Pusa 165* invariably outyielded the best local varieties and the established Pusa types. Characterized as this hybrid is by good stand and comparative resistance to rusts, it is destined to play an important part in the agricultural economy of the wheat-growing tracts for which it is eminently suited. Two more hybrids with *Federation* parentage have, in preliminary tests, done so well for the third year that they have been selected for more extensive tests.

A scheme for the breeding of rust-resistant wheats was started in April 1935 at Simla in collaboration with the rust research investigation. The scheme is financed by the Imperial Council of Agricultural Research and during the few months of the year under review in which it has been in operation numerous crosses have been carried out.

Barley.—Some of the Pusa types of barley were again tried at Karnal in an yield trial against two best Lyallpur types, and the plump-grained Pusa Type 21 headed the yield table. This high yielder was, however, susceptible to white-ant attack in the seedling stage. From comparative chemical analyses of seedlings of the most susceptible and least susceptible types, it would appear that the relatively small amount of silica and the consequent softness

of the tissues might be rendering seedlings of Type 21 more liable to white-ant attack. Eight Pusa types of barley were sent to Rothamsted for preliminary malting tests, and the results are awaited.

Oats.—By crossing Pusa types of oats with *Abundance* and *Scotch Potato* varieties, a number of very promising hybrids have now been secured which will be subjected to yield tests. Among the new varieties imported this year from abroad are *Fulghum* from America and *Belar*, *Gidgee* and *Laggan* from Australia which show promise under Pusa conditions.

Paddy.—Preliminary yield trials carried out with early (autumn) and late (winter) paddies have resulted in favour of Pusa Types 124 and 18 in the first group and Pusa Type 31 in the second group. Among the 42 types of paddies isolated at Karnal from samples collected from the United Provinces and the Punjab, Types 125 and 130 are very promising. Both possess somewhat long and slender grains and stand out well in the field.

Pigeon-pea.—A yield trial with eleven types of Pusa pigeon-peas was conducted on the Pusa Farm and Types 64, 24 and 15 occupied the first three places, but the differences between their mean yields were not significant. Some hybrids combining wilt-resistance with erect habit have been fixed and their seed is being multiplied for yield tests. Experimental data are now available to substantiate the observation previously made that under ordinary conditions, the rotation of pigeon-pea with tobacco may considerably lessen damage due to Fusarium wilt in the former crop.

Gram.—Further yield trials have established that new Types 53, 55 and 58 are definitely high yielders and worthy of trial on outside farms with the old established Types, 3, 17 and 25.

Indian Hemp.—Three strains of Indian hemp (*ganja*) have finally been isolated. Types 1 and 2 are good for *ganja* production, the former giving high yields and the latter producing drug of a superior quality. Type 3, on the other hand, is a tall growing strain, not suitable for *ganja* production and is being maintained only because it throws out the least number of monoecious plants and may thus be of some use in sex-studies. In a smoking test held by the Superintendent of Excise, Patna, two veteran smokers spoke highly of the intoxicating effects of Pusa *ganja* as compared with the Bhagalpur product ordinarily available to them.

Tobacco.—Seed of Hybrid 142 (*Pusa Type 28 X Adcock*), *Adcock* and *Harrison's Special* was raised in large quantities for supply to the Provinces in connection with a co-operative scheme, financed by the Imperial Council of Agricultural Research, to determine what areas in India are suitable for the cultivation and curing of cigarette tobacco. A scheme, financed by the Imperial Council of Agricultural Research for the establishment at Guntur

of a tobacco Sub-station of the Imperial Institute of Agricultural Research, for experimental work on cigarette tobacco was sanctioned. Steps will be taken to acquire land and to commence work in 1936-37.

Potato.—A scheme, financed by the Imperial Council of Agricultural Research for the breeding of improved varieties of potato was started in April 1935 and work commenced at Pusa and on land at Simla adjacent to the rust research laboratory. A large collection of exotic species of Solanum from foreign countries was secured and at the time of writing is under growth. During the year 1935-36 co-operative potato trials are being carried out by Provincial Departments of Agriculture in order to ascertain the most suitable locality for a potato-breeding station in the hills.

Linseed.—In yield trials carried on for three successive years, standard Type 12 has consistently proved superior to all the hybrids except Hybrids 21 (T. 12 X T. 8) and 55 (T. 8 X T. 121) in one year when it was equal to these hybrids. During the year under report, H. 55 went down very much in yield as compared with the previous two years and its place was taken by H. 68 (T. 22 X T. 121) which appears to outyield the former in dry years and in tracts of low rainfall. The reports of yield trials conducted by some Provincial Departments of Agriculture also show H. 68 to be very promising. A study into the correlation between seed-size and oil-content indicates that the oil-content appears to increase with increasing lightness of seed-colour as well as with decrease in seed-size. This is contrary to general belief that the larger the seed the higher the oil-content, and the data available are being further analysed. Retting experiments carried out with Type 124 yielded fibre which, when sent to the Imperial Institute, London, for opinion, was adjudged as coarse but likely to find a good market in England. It is a matter of considerable interest that the ordinary linseed is capable of yielding marketable fibre.

Many other crops are also under investigation, for full details of which and of the numerous points of general interest connected with the work, reference should be made to the Report of the Botanical Section.

Sugarcane.—The sub-tropical types of sugarcane bred at Coimbatore, by their intrinsic agricultural characters, are invading parts of the country where sugarcane growing was formerly hardly considered a profitable proposition. For example, quite recently there has been a big expansion of sugarcane area in the tract commanded by the Nizamsagar canal in the Deccan Hyderabad, because of the introduction of Co. 213. Owing to the light nature of the soil cane growing used to be costly, as bamboo props had to be used to prevent lodging; Co. 213 through its excellent habit does not require such supports and besides grows well with less water. The

Coimbatore canes are receiving increased recognition in foreign countries as well: Co. 281 has proved resistant to "Streak" in South Africa and to "Pine Apple" disease in Porto Rico, Co. 290 is appreciated in Australia for its resistance to "gumming" disease, and Co. 213 has shown utility on low lands overrun with grass in Cuba and is a favourite in Brazil.

The more recent Coimbatore seedlings are steadily making headway in Northern India as further improvements over the Coimbatore types which are already popular. Co. 331, Co. 313 and Co. 299, the seed of which was distributed in large quantities during the year under report after extended trials on the Pusa Farm, have proved extremely successful on the growers' estates. The grower is benefited by their heavy tonnage and the factory by being provided with material for a longer working season, for Co. 299 and Co. 313 are early canes and Co. 331 is a late-season cane. Another new cane which is finding favour is Co. 312 which is distinctly drought resistant.

The work on thick or tropical canes which was started more recently has yielded types which have already earned good opinion. Of the thick seedlings under test on various experiment stations Co. 419 is easily the most outstanding for tropical conditions. It has shown better growth than the wonder cane of Java—P. O. J. 2878—in certain parts of tropical India. Very good preliminary reports have also been received about the performance of Co. 421 from more than one station in Northern India where it promises to be appreciated as a semi-irrigated cane.

At Pusa, an independent area of land measuring some 150 acres is mainly devoted to sugarcane experiments. The testing of new Coimbatore canes for field and other characteristics, tonnage trials with selected varieties, manurial experiments and general problems of cane cultivation form the basis of the work. As stated above, the trials made during the last few years have brought into general cultivation three canes (Co. 331, Co. 313 and Co. 299) which are equally welcome to the grower and the factory owner. Of the new importations, Co. 377, Co. 378, Co. 421, Co. 422 and Co. 423 appear to be promising from the habit of growth. A crop of Co. 210 sugarcane planted in March 1933, which stood in the field for the second year, was periodically analysed, and the results obtained indicate that, provided the weather conditions are favourable, as they were in the present case, there is practically no deterioration in the second year. The condition of the crop throughout the period was abnormally good; the average weight of a single cane was maintained all through; the purity of juice remained high and actually increased from November 1934 to the end of January 1935; in the rainy and humid period between the end of June to October 1934, the sucrose in juice was lower but it rose again to normal after October.

A simple process has been evolved in the Chemical Section for converting paddy husk into activated carbon which is useful in the manufacture of *gur*, white sugar and sugar candy by the open-pan system. Active carbon is imported from abroad at the cost of Rs. 1,000—1,500 per ton. The new process besides being cheaper, is so simple that, if necessary, the active carbon can be manufactured with the equipment available in a village by a person of average intelligence and at a tenth or even lower than the cost of the imported article. The new process carbon possesses the property of clarifying sugarcane juice to water-white colour and of absorbing other suspended and dissolved impurities. It absorbs organic acids. Not only the purity of juice is raised by three or four units but inversion in the boiling of the clarified juice is checked. *Gur* prepared by the active carbon process also possesses better keeping qualities than the best quality *gur* made by the usual process.

Plant Diseases

Research on mosaic and other diseases of sugarcane was continued in pursuance of a scheme financed by the Imperial Council of Agricultural Research since June 1932. The work recorded in previous years on the association of mosaic virus with an organism having a visible cyclostage could not find confirmation in 1935, possibly because the isolation work was started too late in the season. Inoculation experiments with Co. 213 and Co. 210 were also marked by the consistently low percentage of successful infections. A probable cause is an increased resistance of the varieties used both of which have been consistently rogued at Pusa. It has however been demonstrated that maize can be used as a test plant for sugarcane mosaic juice, giving consistently 50-80 per cent infection and providing a longer working season. The thermal death point of mosaic virus appears to lie between 40° and 45° C., in which it resembles that of tomato spotted wilt and of crinkle and mild mosaic of potato. Further work on stinking rot of sugarcane caused by an organism of the *Bacterium pyocyaneum* type has shown that two organisms are present, one giving whitish and the other bluish colonies on nutrient agar. A mixed culture of both was the most effective in bringing about the disease artificially. An investigation into the complaint that the sugar content of canes received in Bihar factories as apparently healthy, but showing reddening of the inner tissues when split longitudinally, was frequently reduced to one half or one third of that of the healthy canes, showed that (*a*) the primary trouble is the prevalence of borers, (*b*) that the fungal and bacterial infection is purely secondary, (*c*) that the loss of sugar due to micro-organisms is very localised, (*d*) and that the reduced sugar content of bored cane is principally due, not to loss of sugar, but to interference with the metabolism of the plant. Seed and soil treatments with an

organic mercury fungicide have proved successful in controlling the seedling disease caused by *Helminthosporium halodes* Drech.

Among the various treatments tested during the year for the control of bunt of wheat, soaking of seed in water either artificially heated or exposed to sun's rays proved very successful: the hot water treatment has the additional advantage of controlling loose smut as well. There is evidence that bunted infection is soil-borne as well as seed-borne and that a one-year rotation will not be sufficient. The burnt and brownish appearance of wheat grains known as "black point" was recorded for the first time at Pusa. On isolating the fungi responsible, 70 per cent of the seed was found to contain *Helminthosporium sativum*, the mycelium occurring within the seed-coat.

Detailed examination of samples of smutted oats collected from 24 areas situated in different wheat-growing provinces confirmed the previous observation that the predominant smut in Northern India is covered smut (*Ustilago kolleri* Wille) and not loose smut [*Ustilago avenae* (Pers.) Jansen.] The dry spray method of applying formalin to smutted oat seed was given an extended trial on nearly 100 acres; the resulting crop was practically free from smut, the infection being below 0·01 per cent.

Experiments carried out with various fungicides show that good control of foot-rot and root-rot of barley caused by *Helminthosporium sativum* can be obtained, by the use of mercury compounds. Such treatment, however, does not prevent secondary infection of the more mature plants by spores from neighbouring fields of wheat and barley or from certain wild grasses which can also act as host. Mercury compounds, formalin and solar heat treatment have all proved ineffective for controlling *Colletotrichum graminicolum* (Ces.) Wilson of sorghum.

Phenyl having been found a good substitute for Kerol for controlling foot-rot in *Piper betle* due to *Sclerotium rolfsii* Sacc. and *Rhizoctonia solani* Khun., pot experiments have been laid down to determine the lowest effective concentration of the more readily obtainable antiseptic.

Among other diseases under investigation may be mentioned the "black shank" and root-rot diseases of tobacco and a white rot disease of grape-vine caused by a new species of *Coniella*.

Insect Pests

As in previous years, sugarcane borers and other insect pests of sugarcane received considerable attention in the Entomological Section. The year's observations with borers show that the top-shoot borer (*Scirpophaga nivella*) is the most common pest; the root-borer (*Emmalocera depressella*), though attacking a fairly large percentage of canes, is responsible for proportionately very small

economic loss. Among the stem-borers *Argyria sticticraspis* predominates, *D. venosata* and *Chilo zonellus* being in very small number. It has also been noticed that the incidence of borers in sugarcane planted in October and in ratoon crops is much higher than in plantings done at the usual time in February. It appears that the October and ratoon crops, by affording food to borers during the period between the harvest of the old and the sprouting of the next crop, act as a source of infestation for February plantings. Work has now been started with a view to determining the comparative incidence of various pests on the most popular of Coimbatore seedling canes. Incidentally it will also be ascertained whether the treatment of setts with insecticides such as lead arsenate, copper sulphate, formalin and creosote, has any effect on the incidence of insect pests on the resulting crop. Among the parasites of cane pests recorded for the first time, a Chalcid wasp (*Trichogramma minutum*) parasitizing the eggs of the root-borer and a species of *Apanteles flavipus* parasitizing the stem-borer throughout the season deserve special mention : they will be studied in detail as they appear to have potentialities of proving very useful in the control of these pests. The morphology and bionomics of *Lepidosaphes*, a probable causative agent of the " yellowing disease " of sugarcane, were studied during the year.

Intensive research has been started to discover the probable insect vector or vectors of the leaf curl disease of tobacco which is on the increase in North Bihar and has been noticed to affect on the Pusa farm as many as 70 per cent. of plants. Of about 400 species of different insects collected from tobacco plants, ten were of the sucking type which is generally associated with virus diseases. Among the latter was a Capsid bug (*Engytatus tenius*) with which transmission experiments have been undertaken.

The Cecidomyid fly mentioned in previous reports as doing heavy damage to linseed flowers has been identified to be a new species of *Dasyneura* and named as *D. lini* Barnes. In view of the proposed extension of linseed cultivation in India, it is feared that this pest is likely to become of major importance in future, and the differential susceptibility of various varieties under cultivation is being investigated.

A detailed study of the influence of different temperatures and humidities on the common grain weevil *Calandra oryzae* has been undertaken. It appears that the weevil if kept below a 60 per cent humidity does not lay eggs and even if a few eggs are laid, they do not hatch at all. The repellant action of some cheap country materials on the weevils is also being investigated.

The life-histories of about eighty insects were studied partly or fully, and some important pests of various crops occurring on the farm were successfully controlled by spraying.

The Spread of Improved Varieties of Crops

The Botanical Section and its Substation at Karnal, and the Agricultural Section at Pusa distributed to Provincial Departments of Agriculture and to private growers the following quantities of seed of improved varieties :—44,054 lb. of wheat, 4,795 lb. of barley, 5,125 lb. of oats, 733 lb. of paddy, 10,119 lb. of gram, 2,052 lb. of pigeon-pea, 618 lb. of linseed, 164 lb. of hemp, 18 lb. of tobacco, 219,765 lb. of sugarcane setts and 1,451 lb. of maize and miscellaneous. The distribution of seed from Pusa was comparatively on a restricted scale than in the previous year and many indents could not be met in full, as the area under *rabi* crops was reduced to grow sugarcane for revenue purposes. The Sugarcane Station at Coimbatore supplied preserved sugarcane seeds of crosses of Co. 349 with Co. 312 and Co. 313 and about 5,000 seedlings of the same crosses to the Sugarcane Research Station at Shahjahanpore. An equal number of seedlings of Co. 213 crossed with Co. 285 and Co. 244 was sent to the Sugarcane Substation at Karnal. In addition, about 200 packets of seed canes containing over 60 varieties were distributed to 90 centres in India, and 27 packets were sent to Natal, Durban, Gold Coast, Kumasi, Formosa, United States of America and Iran.

Agricultural Machinery

The new model 18/30 H. P. Marshall Crude-oil tractor, obtained in exchange of the old 15/30 H. P. model, had a full year's trial and the total expenses for almost 500 working hours worked out at Rs. 1-7-3 per hour. It ploughed 1·12 acres per hour, as compared with 0·66 acre with the Lanz Bulldog 15/30 H. P. semi-Diesel tractor, and 0·90 acre with the Vickers 23/40 H. P. kerosene-oil tractor the respective cost per acre being Rs. 1-4-9, Rs. 2-1-4 and Rs. 6-14-9. In other agricultural operations such as harrow-ploughing, disc-harrowing, grubbing and rolling the Marshall tractor was equally economical. The 9/18 H. P. Farmall row-crop tractor, purchased last year, was used with cultivating attachment in the sugarcane crop and proved very satisfactory. Out of eight tyres and eight tubes originally fitted on four carts specially designed for the Dunlop pneumatic equipment two tyres and three tubes have called for replacement. The axles and hubs are not yet showing any sign of wear and tear.

Cattle

A severe attack of foot-and-mouth disease, after an interval of eight years, overcame the Pusa pedigree herd of Sahiwal cattle and disturbed its metabolic and productive equilibrium with the result that the percentage of cows in milk was reduced to 60 from 66 of the previous year. Despite the intervention of foot-and-mouth disease, the remarkable improvement brought about by the new system of feeding and handling introduced about four years ago will be apparent from the fact that the percentage of cows in milk

stood at only 50·2 in 1931-32, and that the average herd yield per cow per day during the year under report was 19·1 lb. as against 18·7 lb. in the previous year and 13·6 lb. in 1931-32. Eight cows yielded over 8,000 lb. each in a lactation period of ten months, Laruli in her second calving heading the list with an yield of 8,823 lb. One heifer recorded an yield of 6,045 lb. closely followed by five others who all were above the 5,000 lb. limit. With a view to finding out the normal growth standard of the Sahiwal breed, data are being collected of weight and body measurements of every animal in the herd and young stock from birth. These data are expected to show how the stock could be raised most economically with reasonable rapidity, so that inherited growth potentialities may be realised to the fullest extent while they are young. The Chemical Section has isolated a flavour organism which produces butter of quality comparable with that produced with cultures of Nos. 27 and 29 of Hammer.

Karnal.—The results so far achieved with Tharparkar and Hariana types of cows are that the over-all (including dry period) average yield during the year under report worked out for farm-bred Thar-Parkars at 9·1 lb. and for Harianas at 8·8 lb. as compared with 5·6 lb. yielded by both breeds when the foundation stock was purchased in 1923.

Bangalore.—The two indigenous breeds of cattle dealt with at this Farm are the Sindhi and the Gir (from Kathiawar). The over-all average (including dry period) of all cows on the farm which include some Ayrshire-Sindhi crosses rose to 9·0 lb. from 8·3 lb. in the previous year. At the milk depot at Wellington, to which cows in milk are supplied from Bangalore as required and returned to Bangalore when dry, the milking average per diem per head increased from 17·50 lb. in 1933-34 to 18·65 lb. With the decommercialisation of the farm, more attention is now being paid to the development of scientific and research activities. Among the investigations undertaken are those relating to (*a*) standardisation of the method of making Surti cheese, (*b*) the comparative efficiency of different methods of sterilizing dairy utensils and milk bottles and (*c*) the keeping quality of milk under different conditions and in vessels of different kinds (*e.g.* earthenware, glassware, enamelware, porcelain, etc.).

Animal Nutrition

Another year's work by the Physiological Chemist on the influence of high and normal protein feeding on milk production has shown that the consumption of roughage by the group of cattle on the high protein ration is more, which is reflected in increased live-weight. The milk yield for both groups is more or less identical, but the quality is richer in the case of the high protein group. The higher fat content in milk may be due to the higher quantity of fat ingested through the feed and not its higher protein.

The investigation into the comparative values of the mineral composition of grasses grown on selected typical soils in various parts of India has revealed distinct differences traceable to the nature of the soil. For example, the higher lime content of the Pusa soil is reflected in the grass grown therein. Each species of grass has also been found to show a tendency towards a mineral make-up peculiar to itself, *Cynodon dactylon* invariably showing a considerable excess of lime over phosphoric acid and *Pennisetum cenchroides* giving the reverse indication. The excess of phosphoric acid over lime is an unusual phenomenon observed only in two other cases, *viz.*, Guinea-grass and sorghum grown at Bangalore. As previously reported, the mineral contents vary with the stage of maturity, the dead ripe stage producing very poor quality : it has since been ascertained that nitrogen and potash are more influenced by maturity than phosphoric acid and that the effect on lime and magnesia is the least. Each tribe of grass has also been observed to have a decided characteristic in having a high or low sulphate content. For example, the *Chloridae* contain the maximum amount of sulphate, while the *Andropogonae*, the *Panicae*, etc., contain much less.

The influence of progressive ripening of some fodders on the mineral nutrition of cattle is also under study. It has been noticed that early cut fodders produce markedly large volumes of urine which may be definitely attributed to the high amount of alkalis present therein, while some of the later cut fodders are distinctly acidic. The animal experiences difficulty in retaining minerals when the urine becomes acid.

Experiments are in progress to determine the highest phosphoric acid level that a grown up animal is capable of retaining and the effect of supplementing a ration with calcium sulphate. In addition, various physiological studies are in hand, for which reference should be made to the Report of the Physiological Chemist.

Feeding experiments have been commenced at Pusa with Sahiwal bullocks and cows to ascertain the digestibility values of feeds and fodders used, and the suitability and adequacy or otherwise of the ration fed to milch cows.

III. GENERAL ADMINISTRATION

Charge—The headquarters of Dr. F. J. F. Shaw, who held the post of Director, throughout the year, were transferred to Delhi with effect from the 5th November 1934.

The post of Joint Director was held by Mr. Wynne Sayer till the 12th June 1935 when he proceeded on leave for three months and eighteen days; Rao Bahadur B. Viswa Nath officiated as Joint Director during the rest of the year under report.

Staff.—The posts of Imperial Agricultural Chemist, Imperial Entomologist and Imperial Mycologist were filled substantively

during the year by the recruitment through the Public Services Commission, of Rao Bahadur B. Viswa Nath, Dr. Hem Singh Pruthi and Mr. L. D. Galloway who assumed charge on the 22nd August, the 5th September and the 17th December, 1934, respectively. Rao Bahadur Viswa Nath also took over charge of the Bacteriological Section on the 1st November 1934 when that Section ceased to be an independent unit and became part of the Chemical Section. Until the arrival of the permanent Heads of Sections, Mr. P. V. Isaac officiated as Imperial Entomologist, and Mr. J. N. Mukerji, Mr. N. V. Joshi and Dr. M. Mitra, all Class II officers, held charge of the Chemical, Bacteriological and Mycological Sections respectively.

Owing to absences on leave, etc., the following changes in the charge of Sections were made :—

Agricultural Section.—Mr. Arjan Singh from the 13th June 1935, *vice* Mr. Wynne Sayer on leave.

Animal Nutrition Section.—Mr. A.V. Iyer from the 15th March 1935, *vice* Dr. F. J. Warth on leave preparatory to retirement.

Sugarcane Station.—Mr. N. L. Dutt for 14 days during July 1934, *vice* Rao Bahadur Venkatraman on leave.

Extensions

A Scheme for research on genetics of sugarcane and two other schemes, one for breeding potatoes for Northern India, and another for breeding rust-resistant wheats with the collaboration of Prof. K. C. Mehta of Agra College, all financed by the Imperial Council of Agricultural Research, came into operation in May 1934 and April 1935, respectively. The scheme for research into mosaic and other diseases of sugarcane, which was sanctioned in the first instance for a period of three years from 1st June 1932, has been extended by two years, and the life of the Botanical and Sugarcane Substations at Karnal has also been extended for another period of five years, on the understanding that the Botanical Substation will be transferred to the present site of the Botanical Section at Pusa as soon as the Institute itself is moved to Delhi.

Training.—There were 32 candidates for admission to the post-graduate courses beginning in November 1934, of whom 17 were recommended by Provincial authorities for nomination of students. Thirteen applicants were selected for admission : three in Botany, five in Agricultural Chemistry, of whom one left to proceed to England for specializing in animal nutrition, one in Entomology, one in Mycology, and three in General Agriculture. During the year under report, 10 post-graduates completed the two-year course at Pusa : five in Botany, one in Chemistry, one in Entomology and three in Sugarcane Breeding and Cultivation. The one-year course in farm organization, farm management and general farm engineering was completed by one student.

The fifteen-month post-graduate course in Animal husbandry, animal nutrition and dairying was completed by three students in April 1935. Of the two admitted in the new session beginning on 2nd January 1935, one soon left for Scotland for higher studies.

The class of 21 Indian Dairy Diploma students started in November 1933, which was depleted by the defection of one student, was restored to its original strength by the admission of one repeat course student on 1st June 1935. As the year under report was the intervening year no fresh admissions were made. Of the five students considered fit for award of the Diploma, after an examination held at the Allahabad Agricultural Institute, one was a repeat course student from the Bangalore Institute.

A number of students and post-graduate workers were also admitted for periods of work or training in various Sections of the Institute. A group of 15 British soldiers and another of 12 completed at the Bangalore Dairy Farm a six-month vocational course in practical dairying in July 1934 and January 1935, respectively. A third group of 13 admitted in April 1935 was under training at the close of the year. A special course in the flue-curing of tobacco lasting for two months was organized at Pusa, and, although there were a number of applicants, for want of accommodation, only ten students could be admitted to it.

Library.—Publications received in exchange numbered 1,147 while 382 were purchased. Of the 2,022 books, etc., issued on loan, 407 were to scientific workers in the provinces and universities.

Hospital.—There were 370 (new) and 4,882 (old and new) in-patients and 9,138 (new) and 24,232 (old and new) out-patients in 1934, and 411 operations were performed. The health of the residents of the Estate was, on the whole, satisfactory.

IV. ACCOUNTS

The total expenditure for the Institute and its out-stations during the financial year ending the 31st March 1935 amounted to *Rs. 9,68,471 as against Rs. 8,89,676 for the previous year.

Name of establishment	Expenditure. Rs.
General expenditure of the Institute, including the office of the Director, Power and Gas Plants, the Medical and Estate Establishments	2,27,452
Agricultural Section	1,51,525
Botanical Section	42,414
Chemical Section	78,009
Mycological Section	28,655
Entomological Section	59,251
Imperial Dairy Expert	29,857
Bangalore Dairy	1,18,678
Wellington Dairy	39,806
Karnal Cattle Breeding Farm	63,051
Physiological Chemist, Bangalore	49,318
Sugarcane Station, Coimbatore	80,455
	9,68,471

The cost of the Botanical and Sugarcane Substations at Karnal and the schemes for research on mosaic and other diseases of sugarcane and on genetics of sugarcane amounting to Rs. 22,720, Rs. 9,140, Rs. 17,142 and Rs. 6,001, respectively, was met from the funds of the Imperial Council of Agricultural Research.

The receipts of the Institute and its out-stations amounted to Rs.* 2,02,106 as shown below:—

	Sale of dairy produce and livestock	Sale of farm produce	Fees from students	Miscellaneous receipts	Total
	Rs.	Rs.	Rs.	Rs.	Rs.
Pusa Institute . .	14,246	12,540	5,425	7,299	39,510
Bangalore Dairy .	66,388	139	..	7,556	76,083
Wellington Dairy .	40,817	..	..	1,986	42,803
Karnal Farm . .	13,000	19,000	..	3,030	35,030
Coimbatore Sugarcane Station.	..	..	..	8,680	8,680
	..	..	..	..	2,02,106

* Provisional figure.

REPORT OF THE IMPERIAL AGRICULTURIST

(ARJUN SINGH, L. AG.)

(1) AGRICULTURAL SECTION, PUSA

I. CHARGE

Mr. Wynne Sayer held charge of the office of the Imperial Agriculturist till the 12th June 1935, when he left on three months and eighteen days' leave after handing it over to Mr. Arjun Singh, Assistant Agriculturist.

Messrs. L. S. Joseph and P. V. Krishna Iyer held the posts of Cattle Superintendent and Statistician, respectively, throughout the year.

Mr. Arjun Singh, Assistant Agriculturist, was on leave on average pay for sixteen days from the 12th to 27th August 1934.

At the end of the year the following staff were transferred to Delhi as members of the Layout Party:

Mr. Lachman Das Ahuja, Graduate fieldman.

Mr. G. M. Sharma, Graduate fieldman.

Wali Mohamad, Head Jamadar.

Galli Thakur, Acting Fitter and Latheman.

Mushtaq Ahmad, Engine Driver.

Ramlal, Engine Driver.

Ram Uchit, Acting Engine Driver.

Jethua, Fireman.

Ramkhelawan, Fireman.

Bulbul, Jamadar.

Mr. J. N. Bhowmick, Fieldman, was transferred to the Agricultural Sub-station, Karnal.

II. TRAINING OF POST-GRADUATE STUDENTS

Messrs. Khushi Mohamad, B.Sc. (Agri.) and Harbans Singh, B. Sc. (Agri.), Sugarcane Research students, completed their training in October, 1934. Mr. R. K. Tandon, M.Sc., B.Sc. (Agri.), received training in farm organization and general agriculture for one year.

Three students, Messrs. N. K. Jadhav, C. Ekambaram and W. D. E. Perera, from the Animal Husbandryand Dairy Section, finished their training on the 31st March 1935.

Three Agricultural Graduates, Messrs. Anand Mohan Sinha, Prabhunath Prasad and Sukhsagar Lal Gupta were taken in for

post-graduate training in farm organisation and general agriculture from November 1934.

III. SEASON AND CROPS

The total rainfall during the year from the 1st June 1934 to the 31st May 1935 amounted to 41·33 inches against 51·70 inches in the corresponding period of the previous year. At the break of monsoon at its normal time (13th June), the sowing of all the *kharif* crops was successfully completed before the end of the month. Rainfall in the month of July was fairly heavy, and flood in the river at the end of this month destroyed 25 acres of green maize in the *dhab* area. The sluice gate at the main drain outlet being shut, accumulation of heavy rain water flooded 60 acres of *kharif* crop in the Brickfield. Deficient rain in the month of September gave an opportunity for early preparation for *rabi* cultivation. 2·78 inches of rain on the 15th October brought the temperature down and was more than sufficient for the sowing of *rabi* crops.

In view of the shifting of the Institute to Delhi, cropping scheme for *rabi* was materially altered, and the area for seed multiplication was considerably cut down to provide land for revenue crop (sugarcane). 237 acres were thus reserved and left fallow for planting sugarcane. An agreement has been executed by the Samastipur Central Sugar Co., Ltd., to purchase sugarcane grown on 311 acres (plant and ratoon) on the Pusa Farm during the sugar season 1935-36. The yield is estimated to be between 1,50,000—2,00,000 maunds.

The yields of principal crops grown on the Farm are given below :

Crop	Variety	Area in acres	Yield in maunds*	
			Total	Average per acre
Maize—corn	..	71·58	857·95	11·99
Maize—green fodder	..	209·00	21,508·70	102·91
Cowpeas	..	4·49	29·38	6·54
Methi	..	4·33	36·92	8·53
Soybean	..	12·54	150·10	11·97
Green pulses—fodder	..	39·00	4,054·62	103·97
Arhar	T. 15	22·00	318·21	14·46
Do.	T. 24	9·00	135·20	15·02
Do.	T. 51	9·10	94·53	10·39
Do.	T. 80	4·40	41·20	9·36
Do.	Other varieties.	1·81	26·13	14·41
Barley	T. 21	13·27	226·95	17·10
Gram	Miscellaneous varieties.	4·68	54·53	11·65
Oats	B S. I	152·65	2,560·79	16·78

*1 maund = 82·28 lb.

Crop	Variety	Area in acres	Yield in maunds*	
			Total	Average per acre
Oats	B. S. II	2·00	24·22	12·11
Do.	H. C.	3·00	22·97	7·66
Do.	H. J.	6·00	65·97	11·00
Wheat	Pusa 12	6·13	53·40	8·71
Do.	Pusa 52	12·58	101·30	8·05
Peas	P. F. 1	4·17	36·25	8·69
Do.	P. F. 2	·17	2·14	12·59
Do.	P. F. 3	·17	2·25	13·23
Do.	P. F. 4	1·10	16·46	14·96
Do.	P. F. 5	·25	4·85	19·40
Do.	P. F. 6	·22	2·25	10·23
Do.	P. F. 7	·22	2·10	9·50
Do.	P. F. 8	·22	2·56	11·64
Do.	T. 14-1	2·75	56·39	20·51
Do.	Other varieties.	·66	5·45	8·25
Berseem-green fodder	..	108·55	31,057·90	286·12
Sugarcane (Gonhri)	Miscellaneous varieties.	11·51	8,015·00	696·35
Sugarcane (New Area)	Miscellaneous varieties.	28·02	16,195·66	578·00

* 1 maund = 82·28 lb.

IV. SEED SUPPLY

The great demand for seed of the improved varieties of crops could not be met in full as the area under *rabi* crops was reduced to grow sugarcane for revenue purposes.

The following seeds were supplied :—

Variety	Quantity
	lb.
Wheat P. 111	185·13
„ P. 12	41·14
„ P 52	185·13
Oats H. J.	164·56
Soybean	10·28
Maize No. 1	468·19
„ No. 2	4·11
„ No. 3	82·28
Arhar T. 51	164·56
„ T. 80	452·54
„ T. 24	593·68
Sugarcane Co. 299	1,40,318·20
„ Co. 331	77,801·40
„ Co. 313	1,645·70

V. EXPERIMENTAL WORK

The following experiments were conducted by the Agricultural Section during the year under report :

1. Manurial Experiments

(*a*) Permanent manurial and rotation experiments, Punjab field, Blocks C and D.

(*b*) New manurial and rotation experiments in Randomised Blocks conducted on the lines of the above experiments, Punjab field, Block A.

(*c*) Green manuring experiment with sannhemp, *guar* (*Cyamopsis psoralioides*), *meth* (*Phaseolus aconitifolius*) soybean, cowpea and velvet-bean on wheat, Punjab field, Block B.

(*d*) Manurial experiment with rape-cake and superphosphate on sugarcane : different doses of nitrogen with a constant amount of phosphoric acid (P_2O_5), Gonhri field.

(*e*) Manurial experiment with superphosphate and rapecake on sugarcane : different doses of phosphoric acid (P_2O_5) with a constant amount of nitrogen, Gonhri field.

(*f*) Green manuring experiment with berseem on sugarcane, New Area, Dholi Block

(*g*) Effect of silt and farmyard manure on sugarcane yield, New Area, Dholi Block.

2. Varietal yield trials

(*a*) Maize for fodder, Punjab field, Block D.
(*b*) Maize for corn, Punjab field, Block A.
(*c*) Soybean for fodder, Punjab field, Block B.
(*d*) Soybean for seed, Punjab Field, Block D.
(*e*) Gram, Punjab field, Block B.
(*f*) Field-pea, Punjab field, Block B.
(*g*) Pea, Punjab field, Block B.
(*h*) Sugarcane, Co. 210, Co. 213, Co. 313 and Co. 331, Gonhri field.
(*i*) Sugarcane, Co. 213 and Co. 331, Gonhri field.
(*j*) Sugarcane, Co. 210 and Co. 213, New Area, Dholi Block.

3. Miscellaneous Experiments

(*a*) Experiments to see the effect of speed of tractor-drawn implements on soil tilth and crop yield, Brickfield No. 2.

(*b*) Spacing experiment with maize for fodder, Punjab field, Block D.

(*c*) Spacing experiment with maize for corn, Punjab field, Block D.

(*d*) Experiments on the spacing of sugarcane and arrangement of setts at planting, New Area, Dholi Block.

4. Experiments for the Sectional Officers of the Institute

Imperial Agricultural Chemist.—(*a*) Manurial experiment with organic and inorganic fertilizers on sugarcane, New Area, Dholi Block.

(*b*) Phosphate requirements of calcareous soil, Punjab field, Block A.

(*c*) Relative availability of different phosphates in calcareous soil, Punjab field, Block A.

(*d*) Experiments on the depressing effect of potash fertilisers and Gypsum in calcareous soil, Punjab field, Block A.

(*e*) Nitrogen requirements of calcareous soil, Punjab field, Block A.

(*f*) Green manuring experiment with sannhemp, sannhemp tops, *urid* (*Phaseolus Mungo* var. *Roxburghii*) and maize (control) on wheat, North Nepali field.

(*g*) Green manuring experiment with sannhemp, sannhemp tops, *urid* and soybean on wheat, Nepali field.

(*h*) Green manuring experiment with sannhemp and Mexican sunflower on wheat, Nepali field.

(*i*) Experiment on the yellowing of sugarcane leaves, New Area, Dholi Block.

(*j*) Experiment on manuring of potato, Punjab field, Block B.

(*k*) Manurial experiment with Kudada phosphate and its composts on mustard, Punjab field, Block D.

Imperial Economic Botanist.—(*l*) Yield trial with *arhar* (*Cajanus indicus*), Chandman paddock.

Imperial Mycologist.—(*m*) Mosaic tonnage experiments with Co. 213 : mosaic *versus* mosaic-free cane, Silk-house Area.

VI. RESULTS OF FIELD EXPERIMENTS

1. Manurial Experiments

(*i*) *Permanent manurial and rotation experiments in the Punjab field, Blocks C and D.*—In pursuance of the recommendations of the Board of Agriculture 1929, the altered scheme of these experiments was given effect to in 1930-31. The first cycle of the four-year eight-course rotation was completed in 1933-34, and during the year under report, the cropping scheme of the first year rotation was followed up. The yields in different plots are given below :-

Results of permanent manurial and rotation experiments for the year 1934-35

Treatment	A Series			B Series		
	Kharif 1934	Rabi 1934-35		Kharif 1934	Rabi 1934-35	
	Maize grain per acre	Peas grain per acre	Barley grain per acre	Maize grain per acre	Barley grain per acre	Wheat grain per acre
	lb.	lb.	lb.	lb.	lb.	lb.
GROUP I						
1. No manure (Check plot No. 1).	816	426		966	318	
2. Farmyard manure @ 4,000 lb. per acre.	1,244	772		1,198	658	
3. Farmyard manure @ 8,000 lb. per acre.	1,457	1,073		2,041	934	
4. Farmyard manure @ 4,000 lb. per acre *plus* rape cake to supply 20 lb. nitrogen per acre at the time of last interculture.	1,749	1,020		2,149	1,058	
5. Rape cake @ 40 lb. nitrogen per acre, half to be applied just before *kharif* sowing and half to be applied at last interculture.	1,605	568		1,773	618	
GROUP II						
6. Sulphate of ammonia @ 40 lb. nitrogen per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown it is to be applied in one dose in *kharif*.	1,026	310		906	424	
7. Sulphate of potash @ 50 lb. K_2O per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* crop is sown it is to be applied in one dose in *kharif*.	902	332		902	296	
8. Superphosphate @ 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown it is to be applied in one dose in *kharif*.	958	1,126		1,322	760	

Treatment	A Series			B Series		
	Kharif 1934	Rabi 1934-35		Kharif 1934	Rabi 1934-35	
	Maize grain per acre	Peas grain per acre	Barley grain per acre	Maize grain per acre	Barley grain per acre	Wheat grain per acre
	lb.	lb.	lb.	lb.	lb.	lb.
GROUP II—*contd.*						
9. Sulphate of potash @ 50 lb. K_2O per acre and superphosphate @ 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown they are to be applied in one dose in *kharif*.	878	1,324		1,090	772	
10. Sulphate of ammonia @ 40 lb. nitrogen, sulphate of potash @ 50 lb. K_2O and superphosphate @ 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown they are to be applied in one dose in *kharif*.	914	1,084		1,128	1,420	
11. Sulphate of ammonia @ 40 lb. nitrogen and superphosphate @ 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown they are to be applied in one dose in *kharif*.	818	1,276		791	1,100	
13. No manure (Check plot No. 2).	918	280		699	456	
14. Sulphate of ammonia @ 40 lb. nitrogen per acre, sulphate of potash @ 50 lb. K_2O per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown they are to be applied in one dose in *kharif*.	898	211		864	564	
GROUP III.						
12. Green manure in conjunction with a purely cereal rotation.	Green manure	..	856	Green manure	..	508

Treatment	A Series			B Series		
	Kharif 1934	Rabi 1934-35		Kharif 1934	Rabi 1934-35	
	Maize grain per acre	Peas grain per acre	Barley grain per acre	Maize grain per acre	Barley grain per acre	Wheat grain per acre
Group III—*contd.*	lb.	lb.	lb.	lb.	lb.	lb.
15. Effect of green manure and leguminous crop in the rotation.	1,521	356	..	Green manure	1,224	.
16. As for plot No. 15 but with an additional application of superphosphate @ 80 lb. P_2O_5 per acre to be applied with green manure only.	1,909	922	..	Green manure	1,854	..
17. No leguminous crop and no green manure.	886	..	188	738	..	180
18. No manure (Check plot No. 3).	1,036	277	..	810	444	..

(*ii*) *The new manurial and rotation experiments in the Punjab field, Block A.*—This experiment completed its third year of rotation during the year under report. The following are the results of the experiments :

Treatment per acre	Mean yield per plot	
	Kharif Maize No. 2	Rabi Wheat P. 52
	lb.	lb.
A. No manure	9·750	8·370
B. Farmyard manure * @ 8,000 lb.	15·157	15·976
C. Rape cake @ 40 lb. N.	22·395	12·406
D. Amm. Sulphate @ 40 lb. N.	15·375	9·734
E. Pot. Sulphate @ 50 lb. K_2O	11·170	9·058
F. Superphosphate @ 80 lb. P_2O_5	12·469	10·202
G. Pot. Sulphate @ 50 lb. K_2O and Superphosphate 80 lb. P_2O_5.	9·763	8·006
H. Amm. Sulphate @ 40 lb. N, Superphosphate @80 lb. P_2O_5 and Pot. Sulphate @ 50 lb. K_2O.	17·276	14·644
I. Amm. Sulphate @ 40 lb. N and Superphosphate @ 80 lb. P_2O_5.	17·376	13·619
J. Amm. Sulphate @ 40 lb. N and Pot. Sulphate @ 50 lb. K_2O.	14·788	10·651

Fisher's "Z" test was applied and the general effect of treatments was found to be significant at the one per cent. level.

*Composition of farmyard manure :—N—0·86% ; P_2O_5—0·31% and K_2O—0·78%.

Fisher's 't' test was also applied and the differences between the treatments were significant.

Maize

Critical difference = 4·268 (P = ·01).

Critical difference = 3·220 (P = ·05).

Conclusions :— C > I = H = D = B = J > F = E = G = A.

Wheat

Critical difference = 3·187 (P = ·01).

Critical difference = 2·404 (P = ·05).

Conclusions :— B = H = I > C = J = F > D = E = A = G.

(*iii*) *Green manuring experiment in the Punjab field, Block B.*— The experiment was conducted on the lines given in the last year's report. The results are tabulated below :—

Treatment	Mean yield per plot of wheat grain P. 52 (Area of each plot = 0·03 acre)	"z" test	Critical difference
	lb.		
1—Sannhemp . . .	22·71	Not significant.	7·856 (P = ·05)
T. 2—Cowpea . . .	21·52		
T. 3—*Guar* . . .	28·71		
T. 4—*Meth* . . .	20·54		
T. 5—Soybean . . .	15·38		
T. 6—Velvet bean . .	24·11		

Conclusions: T. 3 > T. 4 and T. 5; T. 6 > T. 5; T. 1 = T. 2 = T. 3 = T. 6.

(*iv*) *Manurial experiments with rape-cake and superphosphate on sugarcane Co. 213 in Gonhri field.*—These experiments were laid out in Randomised Blocks with six replications for each treatment. The manures were applied at the time of planting, and the amount of phosphoric acid in rape-cake was deducted from the main dressing of superphosphate.

The results are summarised below :—

Treatment per acre	Sucrose per cent. (Feby.)	Mean tonnage yield per plot (Area of each plot = 0·05 acre)	't' test	Critical difference
		lb.		
T. 1—No manure . . .	15·06	2816·67	Significant at 1 per cent level.	297·18 (P = ·01)
T. 2—40 lb. N + 50 lb. P_2O_5 .	14·37	3379·67		
T. 3—80 lb. N + 50 lb. P_2O_5 .	14·84	3349·67		
T. 4—80 lb. N + 50 lb. P_2O_5 .	13·80	3407·17		
T. 1—No manure . . .	16·06	2472·17	Significant at 1 per cent level.	221·38 (P = ·01)
T. 2—50 lb. P_2O_5 + 40 lb. N .	14·58	3023·67		
T. 3—75 lb. P_2O_5 + 40 lb. N .	14·64	3059·67		
T. 4—100 lb. P_2O_5 + 40 lb. N.	14·81	2923·00		

Conclusions : T. 2 = T. 3 = T. 4 > T. 1.

The conclusions deduced from these manurial trials, carried out for the last three years show that the application of 40 lb. nitrogen in the form of rape cake and 50 lb. P_2O_5 as superphosphate is the most economical treatment in the Pusa soils. Its use along with the Pusa improved method of sugarcane cultivation is therefore recommended.

(v) Green manuring experiment with berseem on sugarcane Co. 213 in the New Area, Dholi Block.—The experiment was designed and laid out during the year under report in Randomised Blocks with six replications. The different treatments included in the experiment are given below—

Treatments per acre :—

T. 1—Berseem green manure.

T. 2—Standard manure :—40 lb. N as rape-cake and 50 lb. P_2O_5 as superphosphate.

T. 3—10 tons farmyard manure.

T. 4—20 tons farmyard manure.

T. 5—Complete minerals :—

40 lb. N as amm. sulphate,

50 lb. P_2O_5 as superphosphate and

40 lb. K_2O as pot. sulphate.

Results of the experiment :—

Treatments	Sucrose per cent (Feby.)	Mean tonnage yield per plot (Area of each plot =0·05 acre)	'z' test	Critical difference
		lb.		
T. 1 . .	17·78	1240·67	Significant at the 1 per cent level.	353·42 (P=·01)
T. 2 . .	16·91	2489·50		259·14 (P=·05)
T. 3 . .	17·15	2452·83		
T. 4 . .	16·91	2809·00		
T. 5 . .	17·39	2088·33		

Conclusions :—T. 4>T. 1, T. 2, T. 3 and T. 5 ; T. 2>T. 1 and T. 5 ; T. 3>T. 1 and T. 5 : T. 5>T. 1.

The experiment is being continued and further observations will be taken of the ratoons next year.

(*vi*) *Effect of silt and farmyard manure on sugarcane yield, New Area, Dholi Block.*—The second year's experiment was carried out with Co. 213, and the results show that silt in bulk is of considerable advantage when ample farmyard manure cannot be obtained.

Treatments per acre	Average tonnage yield per acre	Percentage increase over F. Y. M.
	lb.	
Silt @ 68,556 lb.	61,115	4·4
Farmyard manure @ 32,920 lb. . . .	58,433	..

2. Varietal yield trials

(*i*) *Yield trials with maize for fodder and corn in the Punjab field, Blocks D and A.*—The three farm varieties of maize were tried against the local in double Latin Squares for fodder and

corn separately. The results of the experiments are tabulated below:

Variety	Mean yield per plot (Area of each plot = 0·016 acre)	'z' test	Critical difference
	lb.		
Fodder—			
P. F. 1 . . .	317·56	Significant at the 5 per cent level.	53·19 (P = ·01) 38·46 (P = ·05)
P. F. 2 . . .	322·56		
P. F. 3 . . .	362·50		
Local . . .	299·56		
Corn—			
P. F. 1 . . .	28·21	Significant at the 1 per cent level.	3·663 (P = ·01)
P. F. 2 . . .	32·34		
P. F. 3 . . .	34·95		
Local . . .	29·90		

Conclusions:—Fodder—P. F. 3 > P. F. 2 = P. F. 1 = Local
Corn—P. F. 3 > P. F. 1 = Local;
P. F. 2 > P. F. 1.

(*ii*) *Yield trials with soybean for fodder and seed in the Punjab field, Blocks B and D.*—The results of the second year's trial confirm those given in the last year's report.

Variety	Mean yield per plot (Area of each plot = 0·019 acre)	'z' test	Critical difference
	lb.		
Fodder—			
No. 1—Yellow . .	259·21	Significant at the 1 per cent level.	21·815 (P = ·01)
No. 2—Chocolate .	292·00		
No. 3—Black . .	228·96		
	(Area of each plot = 0·015 acre)		
Seed—			
No. 1—Yellow . .	18·11	Significant at the 1 per cent level.	1·926 (P = ·01)
No. 2—Chocolate .	18·03		
No. 3—Black . .	15·62		

Conclusions:—Fodder—No. 2 > No. 1 > No. 3.
Seed—No. 1 = No. 2 No. 3.

(*iii*) *Yield trial with gram in the Punjab field, Block B.*—The results of the third year's trial with gram varieties are given below :—

Variety	Mean yield per plot (Area of each plot = 0·022 acre).	'z' test	Critical difference
	lb.		
T. 17	22·05	Significant at the 1 per cent level.	6·59 (P = ·01)
T. 25	18·90		
T. 28	19·65		4·93 (P = ·05)
T. 58	24·17		
P. F. 3	23·80		
P. F. 6	14·17		
P. F. 11	27·59		
P. F. 17	20·39		

Conclusions :—P. F. 11 > T. 17, T. 25, T. 28, P. F. 6 and P. F. 17 ; T. 58 > T. 25 and P. F. 6 ; P. F. 3 > T. 25 and P. F. 6; T. 17 > P. F. 6 ; P. F. 17 > P. F. 6 ; T. 28 > P. F. 6.

(*iv*) *Yield trial with field-pea (Pisum arvense) in the Punjab field, Block B.*—The experiment was conducted in a set of four Latin Squares with three varieties.

Variety	Mean yield per plot (Area of each plot = 0·019 acre)	'z' test	Critical difference
	lb.		
P. F. 6	15·33	Not significant.	2·585 (P = ·05)
P. F. 7	14·40		
P. F. 8	17·54		

Conclusions :—P. F. 6 = P. F. 7 < P. F. 8.

(*v*) *Yield trial with pea (Pisum sativum) in the Punjab field, Block B.*—Four varieties of peas were tested in double Latin Squares. The following are the results of the experiment.

Variety	Mean yield per plot (Area of each plot = 0·022 acre)	'z' test	Critical difference
	lb.		
P. F. 1	17·20	Significant at the 1 per cent level.	4·09 (P = ·05)
P. F. 2	21·97		5·65 (P = ·01)
P. F. 3	23·21		
P. F. 4	15·81		

Conclusions :—P. F. 2 = P. F. 3 > P. F. 1 = P. F. 4.

(*vi*) *Tonnage yield trial with sugarcane varieties Co. 210, Co. 213, Co. 313 and Co. 331 in Gonhri field.*—The varieties were tried in Randomised Blocks with six replications for each. The crop was cut in the middle of the cane season.

Variety	Mean yield per plot (Area of each plot = 0·05 acre)	't' test	Critical difference
	lb.		
Co. 210	3237·17	Significant at the 1 per cent level.	224·65 (P=·01)
Co. 213	3049·00		162·45 (P=·05)
Co. 313	3065·17		
Co. 331	3911·33		

Conslusions :—Co. 331 > Co. 210, Co. 213 and Co. 313
Co. 210 > Co. 213 and Co. 313.

(*vii*) *Tonnage yield trial with sugarcane varieties Co. 213 and Co. 331 in Gonhri field.*—The experiment was laid out according to Beaven's half-drill-strip arrangement with fourteen replications for each variety. The crop was allowed to stand over and harvested at the end.

	lb.
Area of each plot = 1/20 acre.	
Mean difference in favour of Co. 331 . . .	885·00
Standard error	49·38
Critical difference (P = ·01)	148·73
Result—Co. 331 > Co. 213.	

(*viii*) *Tonnage yield trial with sugarcane varieties Co. 210 and Co. 213 in the New Area, Dholi Block.*—This experiment has now been carried out for five years, and it will be seen that during the year under report, Co. 210 has excelled Co. 213. The tonnage yield of these varieties depends much upon the monsoon variation and local soil conditions. The experiment was conducted on same lines as before with twelve replications for each variety.

	lb.
Area of each plot = 1/20 acre. . .	
Mean difference in favour of Co. 210 . . .	463·33
Standard error	40·82
Critical difference (P = ·01)	126·78

3. Miscellaneous Experiments

(*i*) *Effect of speed of tractor-drawn implements on soil tilth and crop yield.*—The third year's experiment was conducted in Brick-field No. 2 on the lines detailed in the two previous reports.

A—Ploughing and harrowing at 5 miles per hour.

B—Ploughing and harrowing at 2½ miles per hour.

The 5-furrow plough working at 2½ m.p.h. kept the furrows open and the furrow slice was not broken properly, while the 3 furrow plough working at 5 m.p.h. turned the furrows completely over, the furrow slice was pulverised thoroughly and the ploughed surface was smooth.

Oats B. S. I. was grown in *rabi* and the results given below show that the higher speed does not affect crop production.

Area of each plot=0·095 acre.

Mean difference in favour of 5 miles speed=0·306 lb.

Standard error=1·856 lb.

Critical difference (P=·05)=3·916 lb.

(ii) Spacing experiments with maize P. F. 2 for fodder and corn in the Punjab field, Block D.—The results of this year's experiments indicate clearly that the spacing of nine inches within rows gives a higher yield of fodder and corn than the other treatments. The trial was conducted in double Latin Squares as before.

Spacing	Mean yield per plot (Area of each plot = 0·016 acre)	'z' test	Critical difference
	lb.		
For fodder—			
T. 1—9 inches . .	316·19	Significant at the 1 per cent level.	36·51 (P=·01)
T. 2—12 inches . .	277·75		
T. 3—15 inches . .	279·19		
T. 4—18 inches . .	257·06		
For corn—			
T. 1—9 inches . .	25·25	Significant at the 1 per cent level.	3·10 (P=·01) 2·24 (P=·05)
T. 2—12 inches . .	22·49		
T. 3—15 inches . .	22·20		
T. 4—18 inches . .	20·74		

Conclusions :—T. 1>T. 2=T. 3=T. 4.

(iii) Experiments on the spacing of sugarcane and arrangement of setts at planting with Co. 210 in the New Area, Dholi Block.—This experiment was conducted for the second time during the period under report. The results show that the spacing of

2½ feet is not advantageous, as more setts are required. The arrangement of 'eye to eye' with ordinary seed is advisable, while 'end to end' with good seed is equally good.

Treatment	Average tonnage yield per acre	'z' test	't' test
	lb.		
3 feet spacing	53,887	Not significant	Not significant
2½ feet spacing. . . .	53,313		
End to end	53,962	Do. .	Do.
Eye to eye	53,238		

4. Sectional Experiments

The results of the experiments conducted for the Sectional Officers of the Institute have been incorporated in their respective reports.

VII. SUGARCANE VARIETAL WORK

The importation of new varieties of sugarcane from Coimbatore and their testing and multiplication were continued. Three new varieties of cane Co. 432, Co. 433 and Co. 434 were received in March 1933.

The importance of this work can be indicated by stating that the three varieties of cane Co. 331, Co. 313 and Co. 299, the seed of which was distributed in large quantities last year after all sorts of trials, have proved extremely successful on the growers' estates, and there is a regular demand for the seed of these varieties. When fully spread, the grower will be benefitted by their heavy tonnage and the factory by running the mills for longer period, as Co. 299 and Co. 313 are early canes and Co. 331 a late one.

The following varieties of cane were grown on a field scale during 1934-35.

Co. 210, Co. 213, Co. 214, Co. 281, Co. 299, Co. 303, Co. 313, Co. 331, Co. 337, Co. 339, Co. 343, Co. 344, Co. 387, Co. 388, Co. 393, Co. 395, Co. 396 and Co. 397.

These have again been planted on a commercial basis. The average yield and analysis results for the year under report are given below :—

Results of chemical analysis and tonnage yields of sugarcane varieties during 1934-35

Sugarcane variety	Field	Sucrose per cent in juice				Area in acres	Average tonnage yield per acre in maunds*
		Novr. 1934	Decr. 1934	Jany. 1935	Feby. 1935		
Co. 210	New Area	15·91	18·54	14·88	16·90	3·21	689·78
	Gonhri	...	...	...	...	·5475	726·80
Co. 213	New Area	...	16·44	16·82	17·96	8·59	531·80**
	Gonhri	...	...	...	...	6·2101	795·57
Co. 214	New Area	14·98	17·04	17·57	17·41	2·45	466·39
	Gonhri	...	...	...	...	·37	330·00
Co. 281	New Area	11·64	17·32	17·32	19·52	2·467	712·20
Co. 299	New Area	13·24	16·37	17·43	16·63	4·82	500·85
	Gonhri	15·33	...	...	...	·37	506·30
Co. 303	New Area	...	...	...	...	·68	495·39
Co. 313	Gonhri	13·40	15·76	17·05	17·47	·9175	711·87
	New Area	...	...	...	...	1·12	656·89
Co. 331	New Area	...	14·04	15·11	16·55	2·75	761·53
	Gonhri	...	...	...	...	2·1309	907·48
Co. 337	Gonhri	16·61	19·87	17·85	16·93	·74	343·90
Co. 339	Gonhri	15·36	16·85	16·44	15·40	·22	383·60
Co. 343	New Area	...	14·35	16·79	16·92	·48	462·67
Co. 344	Do.	16·22	16·70	16·18	15·48	·62	510·12
Co. 357	Do.	14·75	15·99	17·24	17·31	·082	545·73
Co. 358	Do.	14·43	15·71	16·70	18·57	·046	450·00
Co. 393	Do.	15·93	17·04	17·05	18·41	·046	440·65
Co. 395	Do.	14·59	16·67	16·72	17·70	·092	667·39
Co. 396	Do.	17·72	17·07	17·36	17·91	·046	378·26
Co. 397	Do.	16·19	16·04	17·26	16·84	·092	367·17

* 1 maund = 82·28 lb.
** Attacked by borers.

The following varieties were under multiplication in the nursery at New Area—

(*a*) Varieties imported from Coimbatore in 1931—Co. 347 and Co. 348.

(*b*) Varieties imported from Coimbatore in 1932—Co. 381, Co. 382, Co. 384 and Co. 386.

(*c*) Varieties imported from Coimbatore in 1933—Co. 360, Co. 366, Co. 368, Co. 369, Co. 370, Co. 371, Co. 373, Co. 374, Co. 375, Co. 377, Co. 378, Co. 381*, Co. 382*, Co. 384*, Co. 386*, Co. 391, Co. 394, Co. 408, Co. 412, Co. 413, Co. 417, and Co. 419.

(*d*) Varieties imported from Coimbatore in 1934—Co. 420, Co. 421, Co. 422, Co. 423, Co. 424, Co. 425, Co. 426, Co. 427, Co. 428, Co. 429, Co. 430, Co. 431, Co. 500, Co. 501, Co. 502, Co. 503, Co. 504, Co. 505, Co. 506, Co. 507, Co. 508, Co. 509, Co. 510, Co. 511, Co. 512, Co. 513, Co. 514, Co. 515, and Co. 516.

Out of the above varieties Co. 360, Co. 373, Co. 408 failed to germinate as they were all eaten up by white ants.

* Repeats.

Out of 50 varieties that survived, 45 were analysed chemically. The results were not conclusive, as the material subjected to analysis was very little—one cane only in many varieties. Co. 377, Co. 378, Co. 421, Co. 422 and Co. 423 look promising from the habit of growth and will be carefully watched next year.

VIII.—MISCELLANEOUS CROPS GROWN FOR THE SECTIONAL OFFICERS OF THE INSTITUTE

(1) Crops were grown for the Imperial Economic Botanist in the Agricultural Section for seed multiplication as well as for varietal yield trial. The average yield per acre of each variety is given below:

Crop	Field	Area in acres	Outturn of grain in lb.		
			Actual	Per acre	
Arhar T.15	Chandman paddock.	0·109	201·71	1850·55	
T.16	Do.	0·109	151·11	1386·33	
T.24	Do.	0·109	229·01	2101·00	
T.41	Do.	0·109	174·82	1603·85	
T.51	Do.	0·109	148·92	1366·24	
T.64	Do.	0·109	234·89	2154·03	
T.69	Do.	0·109	180·58	1748·44	
T.80	Do.	0·109	175·27	1607·98	
T.50	Do.	0·109	166·83	1530·55	
T.82	Do.	0·109	190·46	1747·34	
Local	Do.	0·109	195·84	1796·69	
T. 5	Bhograsan	5·00	6128·20	1025·60	
T.24	Do.	9·00	11139·50	1237·70	
T 51	Do.	9·10	7792·50	855·10	
T.80	Do.	4·40	3404·60	773·70	
Safflower T.1	Punjab field Block D.	0·0625	70·40	1126·40	
T.2	Do.	0·0625	45·80	732·80	
T.3	Do	0·0625	40·10	641·60	
T.4	Do.	0·0625	61·20	979·20	
Barley T.21	Do.	2·00	2037·60	1018·80	
T.21	N. Pangarbi	5·75	12054·80	2096·49	
Hibiscus T.3	Nepali	0·50	52·40	..	Crop harvested and utilised by the I. E. B.
T.6	Do.	0·50	83·30	..	
New Hibiscus (seed).	Do.	0·10	29·80	..	
New Hibiscus (fibre).	Do.	0·50	59·70	..	
Oats B. S. II	Brickfield No. 2	2·00	1992·80	996·40	
Oats H. J.	Do.	6·00	5428·80	904·80	
Oats H. C.	Do.	3·00	1890·50	630·17	

(2) The following crops were grown in small plots for the Imperial Entomologist during the year under report:

Kharif

Maize, *juar* (*Andropogon Sorghum*), *bajra* (*Pennisetum typhoideum*), *mung* (*Phaseolus radiatus*), *urid* (*Phaseolus Mungo* var. *Roxburghii*), cowpeas, soybean, *meth* (*Phaseolus aconitifolius*), *guar* (*Cyamopsis psoralioides*), sannhemp, Roselle, *til* (*Sesamum indicum*), sweet potato, turmeric, ginger, castor, sunflower and sugarcane—Co. 210, Co. 213, Co. 214 and Co. 331 (February, 1934); Co. 210, Co. 213, Co. 299 and Co. 331 (February, 1935).

Rabi

Wheat, oats, barley, gram, peas, Java indigo, lentil, chillies, potato, tobacco, linseed, mustard, and safflower.

IX.—MACHINERY

1. Steam Tackle

The steam ploughing tackle consisting of two ploughing engines, one gang-plough, one disc-harrow, one roller and one spring tine-cultivator was transferred to Delhi, at the end of May, 1935 for levelling agricultural lands at the new site of the Imperial Institute of Agricultural Research.

2. Tractors

Trials with tractors (crude-oil and kerosene oil), the details of which have been given in the last year's report were continued. The new model 18/30 H. P. Marshall crude-oil tractor which was received in exchange of the old 15/30 H. P. model worked satisfactorily. The total number of working hours with four tractors was 931·84 as compared with 957·93 in the last year with three tractors. The working cost and fuel consumption were considerably reduced during the year under report. This is due to the fact that the Marshall tractor was of a new design and the Lanz Bulldog and McCormick Deering were thoroughly overhauled and had new cylinders and pistons put on last year. The comparative figures of their working expenses are as follows:

Name of tractor	1933-34		1934-35	
	Fuel per hour	Total expenses per hour	Fuel per hour	Total expenses per hour
	Galls.	Rs. a. p.	Galls.	Rs. a. p.
Lanz Bulldog (crude oil).	1·50	3 14 6	1·24	1 6 3
Marshall (crude-oil) .	..	..	1·20	1 7 3
McCormick Deering (kerosene oil).	2·69	6 0 9	2·56	4 5 10

The 9/18 H. P. "Farmall" row crop tractor, purchased last year, was used with cultivating attachment in the sugarcane crop and proved very satisfactory. The working details for this tractor are being collected.

The results of the year's working with four tractors are given in the following statements:

Statements showing the output, consumption and cost of cultivation by tractor for the year 1934-35

1. Summary of the work done

Name of Tractor	Working Hours	Ploughing		Harrow ploughing		Disc Harrowing		Grubbing		Reaping		Rolling		Drilling	
		Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres
Lanz Bulldog semi-Diesel 15/30 H. P.	204·91	15·00	10·00	...	...	12·50	21·50	124·41	232·00	22·00	68·00	31·00	93·00	...	...
Marshall Fuel Diesel 18/30 H. P.	498·12	71·66	80·25	98·55	181·00	26·66	49·20	267·25	480·00	...	...	24·50	76·00	9·50	20·00
McCormick Deering 15/30 H. P. (K. oil).	170·66	...	...	28·00	50·00	52·25	119·00	77·91	174·00	...	...	5·0	18·00	7·50	27·00
Vickers 28/40 H. P. (K. oil).	58·15	5·50	5·00	...	...	47·50	102·00	5·15	12·50	...	...	...	...	...	...

2. Acreage per hour

Name of Tractor	Working Hours	Ploughing	Harrow ploughing	Disc Harrowing	Grubbing	Reaping	Rolling	Drilling
Lanz Bulldog semi-Diesel 15/30 H. P.	204·91	0·66	...	1·72	1·86	3·09	3·00	...
Marshall Fuel Diesel 18/30 H. P.	498·12	1·12	1·83	1·85	1·79	...	3·10	2·10
McCormick Deering 15/30 H. P. (K. oil)	170·66	...	1·78	2·27	2·23	...	3·29	3·60
Vickers 28/40 H. P. (K. oil)	58·15	0·90	...	2·14	2·38	...	...	...

3. Fuel Consumption

Name of tractor	Working hours	K. oil		Crude oil		Petrol		Engine and gear oil		Grease		Waste	
		Total	Per hour	Total	Per hour	Total	Per hour	Total	Per hour	Total	Per hour	Total	Per hour
		galls.	galls.	galls.	galls.	galls.	galls.	galls.	galls.	lb.	lb.	lb.	lb.
Lanz Bulldog Semi-Diesel 15/30 H. P.	204·91	10·56	0·05	255·53	1·24	...	...	38·90	0·16	32·00	0·15	9·50	0·04
Marshall Fuel Diesel 18/30 H. P. .	498·12	5·11	0·01	601·30	1·20	...	...	100·47	0·20	82·50	0·16	29·25	0·05
McCormick Deering 15/30 H. P. (K. oil).	170·66	436·75	2·56	...	...	14·00	0·08	33·78	0·19	33·00	0·19	9·00	0·05
Vickers 28/40 H. P. (K. oil) . .	58·15	218·84	3·27	...	...	2·50	0·03	15·75	0·23	9·00	0·13	1·80	0·02

4. Analysis of total cost

Name of tractor	Kerosene oil	Crude oil	Petrol	Lubricants and waste	Wages of mistries and water carriers	Wages of repairing staff	Spare parts	Total	Expenses per hour
	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
Lanz Bulldog Semi-Diesel 15/30 H. P. .	7 13 1	111 12 7	...	56 15 0	38 7 6	50 0 0	20 6 6	285 6 8	1 6 8
Marshall Fuel Diesel 18/30 H. P. . .	4 10 2	263 0 10	...	263 13 7	71 15 6	78 11 0	42 10 0	724 13 1	1 7 8
McCormick Deering 15/30 H. P. (K. oil) .	320 12 0	...	22 12 0	88 4 0	30 8 2	104 7 0	178 11 6	745 6 8	4 5 10
Vickers 28/40 H. P. (K. oil) . . .	142 14 6	...	3 4 0	41 13 11	16 10 10	22 6 0	138 15 0	366 0 3	6 4 8

5. COST PER ACRE

Name of tractor	Ploughing	Harrow-ploughing	Disc-harrowing	Grubbing	Reaping	Rolling	Drilling
	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
Lanz Bulldog Semi-Diesel 15/30 H. P.	2 1 4	...	0 12 11	0 11 11	0 7 2	0 7 5	...
Marshall Fuel Diesel 18/30 H. P. .	1 4 9	0 12 8	0 12 7	0 11 3	...	0 7 6	0 11 0
McCormick Deering 15/30 H. P. (K. oil)	...	2 6 9	1 14 3	1 15 3	...	1 5 10	1 3 5
Vickers 23/40 H. P. (K. oil) . .	6 14 9	...	2 14 10	2 10 3	...	...	...

Statement showing the cost of belt pulley work by tractors for the year 1934-35

Name of tractor	Working hours	Fuel and lubricants, etc.	Wages of mistries and water carriers	Wages of repairing staff	Total	Expenses per hour
		Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
McCormick Deering 15/30 H. P. (K. oil) .	108·00	230 0 6	23 4 2	8 6 8	261 11 4	2 6 9
Vickers 23/40 H. P. (K. oil) . .	8·50	25 12 4	2 14 8	...	28 11 0	3 5 11

8. Dunlop pneumatic equipment for bullock carts

After the preliminary tests, the results of which have been published in the September issue of the *Agriculture and Livestock in India*, 1934, the four trial carts fitted with Dunlop pneumatic equipment were constantly used throughout the year for ordinary carting work on the Farm for testing the life of the tyres and tubes. There was no sugarcane carting for the mill, as all the cane grown during the year was utilised in planting. Out of the eight tyres and eight tubes originally put on these carts, two tyres and three tubes were damaged and subsequently replaced with new ones. No sign of wear and tear is yet visible on the axles and hubs.

Twelve standard wooden cart bodies were made in the Farm workshop, fitted with Dunlop pneumatic equipment and sent to Delhi for use at the New Site of the Imperial Institute of Agricultural Research.

Three standard wooden cart bodies fitted with Dunlop equipment were made for the Raja Sugar Factory and the Manager, Gauri Bazaar Factory, at standard rates for use as demonstration carts in those districts.

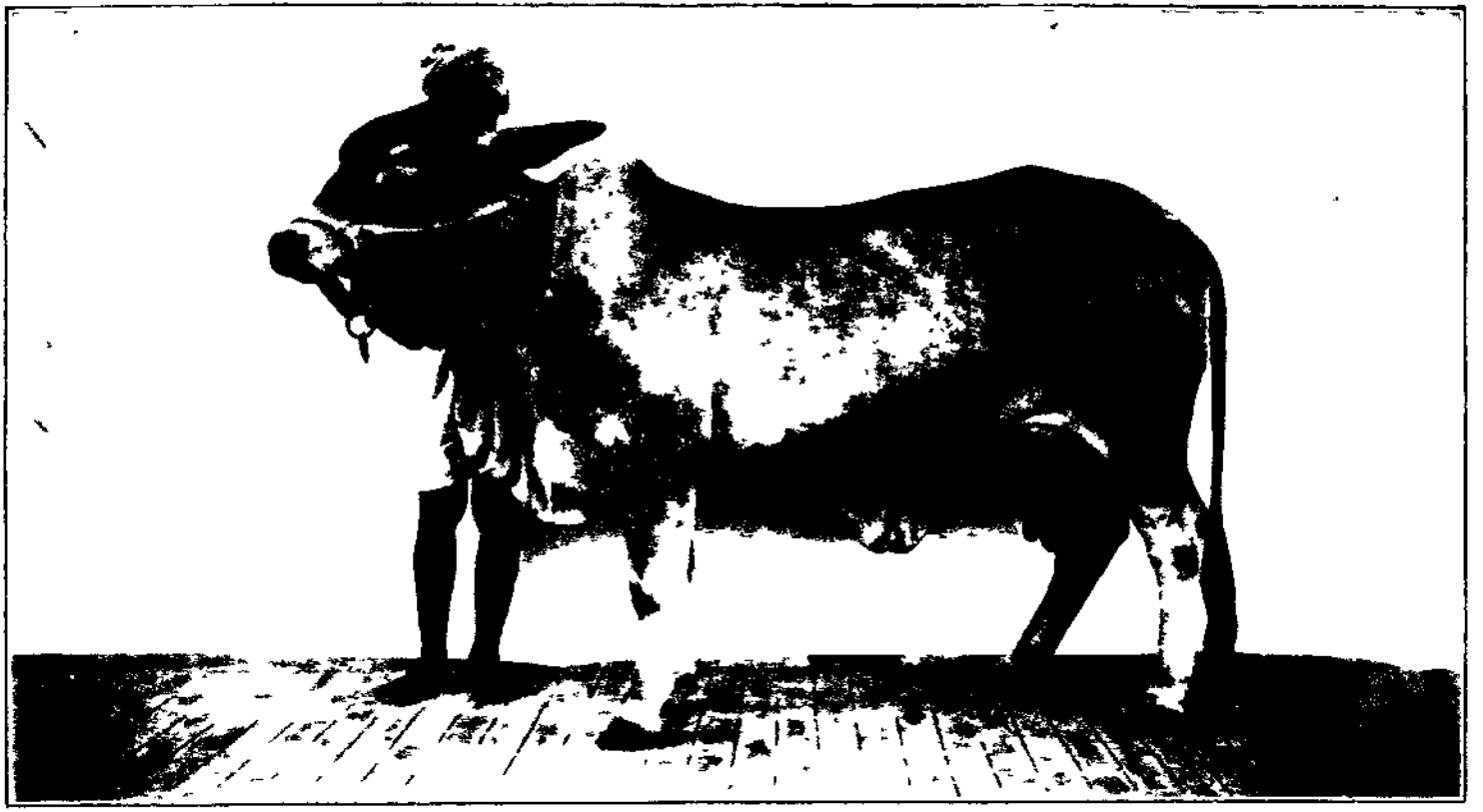
X. CATTLE BREEDING

The strength of the Pusa Pedigree Sahiwal herd at the beginning of the year under report was 217 head. The cows in the milch herd numbered 54, and the total milk produced during the year was 2,52,732 lb. as against 3,00,690 lb. during the last year. The percentage of cows in milk was sixty as compared with sixty-six in the previous year.

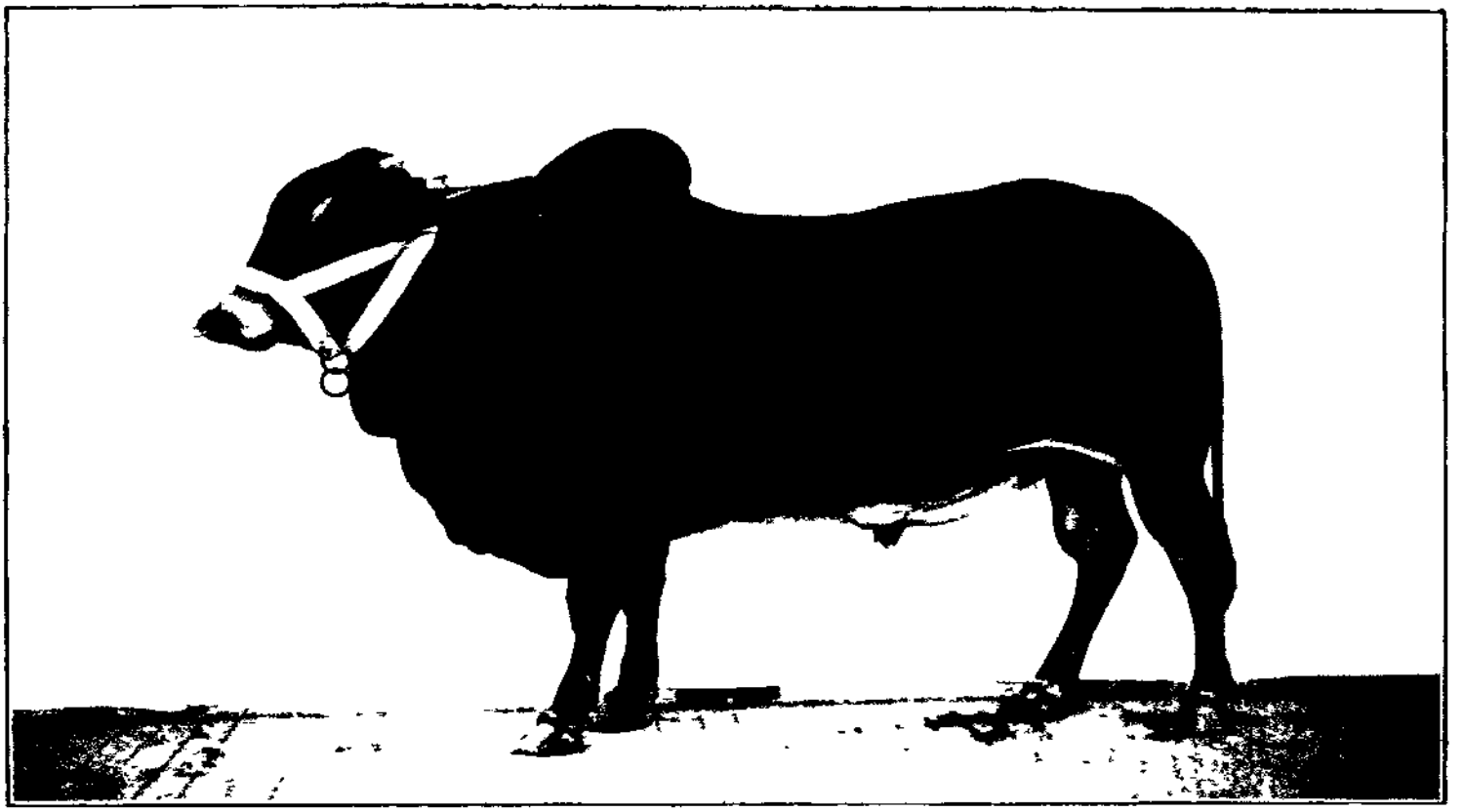
While the herd was settling down to their normal condition after last year's earthquake disaster, they were, unfortunately, visited by a severe form of Foot and Mouth disease in January 1935, and this not only disturbed their metabolic and productive equilibrium, but it has left its marks on their constitution up to the time of writing this report. It may be noted that the herd was free from any attack of Foot and Mouth disease during the last eight years. The economic importance of Foot and Mouth disease is keenly realised in the severe losses from the long period of inactivity of the affected animals, from the loss in body weights, from diminished milk production, and through the loss of young calves below three months' age.

The following experiments that were in progress and mentioned in the previous report, are being continued, but there was a definite set-back during the period of the outbreak of the disease in all animals under various experiments. They are gradually coming back to their normal.

1. Special calf rearing experiments in relation to early maturity.



Chanda No. 653—Early maturity specialized Sahiwal heifer. Milk yield: 6 846 lb. in 261 days. She is expected to give over 7 500 lb. in her first lactation



Jaswant No 635—Early maturity specialized Sahiwal bull He started service at the age of one year and ten months

2. Four time milking of cows.

3. Pre-milking and handling of heifers and cows.

4. Determination of the herd butter fat.

5. The early maturity experiments.

Milk Yield.—Inspite of the severe attack of the Foot and Mouth disease, the average herd yield per cow per day was 19·1 lb. against 18·7 lb. in last year.

TABLE III in Appendix shows the best cows and heifers which have completed their lactation during the year. There were eight 8,000 lb. milkers and one 6,045 lb. heifer and five heifers over 5,000 lb.

TABLE IV in Appendix shows the number of cattle sold during the year and the prices obtained. This year better prices were realised than last year, and the demand for the pedigree stock continues.

Calf Rearing.—The year showed a higher percentage of mortality among the pail-fed calves—from 13·7 to 24·2 which was due to the unfortunate incident of Foot and Mouth disease among the young calves. Eleven calves died from this disease.

To find out the normal growth standard of the Sahiwal breed, data are being collected of weight and body measurements of every animal of this herd and young stock from birth. These data will be of great value to show how the stock could be grown most economically with reasonable rapidity, so that inherited growth potentialities may be realised to the fullest extent while they are young.

In collaboration with the Imperial Agricultural Chemist, Pusa, a series of feeding experiments, to find out a suitable balanced ration for the dairy cattle under Indian conditions, were conducted and the results will be published in due course.

XI. PUBLICATIONS

1. Sayer, Wynne . . Feeding and handling experiments on the Pusa pedigree Sahiwal herd (Second report, 1933-34), *Agri. & Livestock in India*, 4, 1934, 481—494.

2. ———— . . Tests on Dunlop pneumatic equipment for farm carts, Season 1933-34, *Agri. & Livestock in India*, 4, 1934, 524—533.

3. ———— . . Tables of pail-fed calf weights during ordinary and special feeding, *Agri. & Livestock in India*, 4, 1934, 633—644.

XII. PROGRAMME OF WORK FOR 1935-36

1. Cultivation of sugarcane on an area of 322 acres on a commercial basis.

2. Continuation of the permanent manurial and rotation experiments in the Punjab field.

3. Continuation of the new manurial and other experiments which are at their stage of completion.

4. Isolation of pure types of cowpeas.

5. Study of new sugarcane varieties which have been received from Coimbatore.

6. Experiments with various types of motor tractors and general tractor implements for collection of data and determination of most suitable types of tractors and implements for Indian conditions.

7. Line breeding investigations with a pedigree herd of Sahiwal cattle with special reference to the transmission of milch characters.

8. Special feeding of young calves with a view to early maturity to lengthen the profit period of the average Sahiwal cows and bulls.

9. Cultivation of 300 acres of land at the Agricultural Substation, Karnal.

10. Training of Post-graduate students.

11. Touring and advisory.

12. Gradual shifting of the Section to Delhi and Karnal.

(2) AGRICULTURAL SUB-STATION, KARNAL

The Imperial Agricultural Sub-station, Karnal, was opened in October, 1935, and Mr. Kashi Ram, Superintendent, Botanical Sub-station, Karnal, remained in charge. He was assisted by Mr. Lachman Das, Graduate Fieldman, Agricultural Section, from the 12th December, 1934. On transfer of these officers to Delhi in May 1935, Mr. Hukam Singh, B.Sc. (Agri.), Offg. Superintendent, Botanical Sub-station, Karnal took over charge and Mr. J. N. Bhowmick relieved Mr. Lachman Das.

Under orders from the Director of the Imperial Institute of Agricultural Research, the Superintendent, Imperial Cattle Breeding Farm, handed over to the Superintendent, Botanical Sub-station, Karnal, an area of 119·17 acres of land (from Plot No. 5, I. C. B. Farm, Karnal). It was taken over on the 28th September 1934, on behalf of the Imperial Agriculturist, Pusa, for growing fodder for cattle engaged at the new site of the Imperial Institute of Agricultural Research, Delhi. Another 198 acres of land from Block Nos. 4 and 5 were handed over to the Superintendent, Botanical Sub-station, Karnal, on the 16th June 1935.

In Block No. 5, an area of 53·5 acres was put under gram T. 17 and 63·25 acres under oats hybrid J. 1,323 maunds of oats and 968·03 maunds of gram were obtained from the fields as a result of harvest. The average yield per acre for oats hybrid J. was 20·32 maunds and that for gram T. 17 was 18·1 maunds. Condition of crops was satisfactory except that the frost and hailstorm did some damage to gram, and showers in April caused the oats to lodge to some extent.

Forty pairs of Malvi bullocks were purchased from Central India in March—April and were sent to Karnal. Twenty-five pairs out of these were shifted to Delhi in May for the layout and levelling work at the New Imperial Institute of Agricultural Research and fifteen pairs were retained at Karnal for the cultivation work at the Agricultural Sub-station.

502 maunds of *bhusa* and 142·55 maunds of concentrates (oats and gram in 1 : 1 ratio) were sent to Delhi for the feed of cattle engaged in laying out lands for the Imperial Institute of Agricultural Research. 120 maunds of oats was also supplied to the Superintendent, Imperial Cattle Breeding Farm, Karnal, in exchange of 120 maunds of gram.

3. STATISTICAL BRANCH

(P. V. KRISHNA IYER, M.A., STATISTICIAN)

Statistical work

Mr. P. V. Krishna Iyer, M.A., held the post of Statistician during the year under review.

In addition to advice and assistance given to workers of the different Sections at the Institute and to outsiders the following statistical studies were carried out.

The records of the Pusa herd were examined carefully in order to estimate the capacity of the various bulls, past and present, in improving their stock. The bulls were judged by their capacity to improve the milk yield of the progeny over the dam.

The possibility of applying in plant breeding work "The New Method of Goodness of Fit" put forth by Karl Pearson was discussed with the Assistant Economic Botanist and a note illustrating the method was sent for his use and guidance. The method is more reliable on account of the fact that the assumptions involved in it are fewer than "χ^2" test. But unfortunately it is of more practical value in anthropometry than plant breeding.

Research work

Are assumptions in regard to fertility gradient curves in experimental plots valid? A short study of the behaviour of land in different years with same and different crops, *viz.*, paddy, sorghum and cotton was made with some figures supplied by the Imperial Agricultural Chemist. In the case of paddy there was close correlation between the yields in different years from the same field. But in the case of other crops the correlation was very small showing thereby, that the method of adjustment of yield using previous crop records is not applicable for crops like sorghum and cotton.

Statistical study of milk yields—Sahiwal herd.—The records of the dairy were carefully gone through and data collected as to supply information on the following points connected with the Sahiwal herd :—(1) Mean and standard deviation of milk yield, service period, dry period, calving interval and age at first calving, (2) Relations between total milk yield, age, season of calving, service period and dry period, (3) Average gestation period for bull calves and cow calves, (4) Lactation curves for cows calving at different ages in different seasons.

The results of the analysis so far completed are given below :

The age at first calving was available for 411 cows and it was found that the Sahiwal herd in general could be expected to calve at the age of three years and 4·78 months. The distribution was not normal. The mode was at three years and 6·93 months.

In order to find out whether there was any improvement in the stock with the lapse of time, an attempt to divide the data into the following groups was made :—

Group I Cows calved during 1904—1913.
Group II ,, ,, ,, 1914—1923.
Group III ,, ,, ,, 1924—1934.

The results of the analysis are shown below :

Mean	(Distance between mean and mode in months)	Standard deviation (months)
Group I.—3 Yrs. 3·58 Mths. ± ·5083	·8984± ·7806	3·77± ·3595
Group II.—3 Yrs. 9·36 Mths. ± ·4222	·6150± ·7514	5·39± ·2985
Group III.—3 Yrs. 1·24 Mths. ± ·3700	2·5931±1·0764	5·14± ·2616
All together 3 Yrs. 4·78 Mths. ± ·3117	2·1507± ·5739	6·32± ·2204

The foregoing analysis shows that the age at first calving of Group III cows was less than that of Group I and Group II. This may perhaps be due to the improvement of the herd stock during the last ten years.

The average service period of the Pusa Sahiwal herd for the years 1904—1934 was found to be approximately 197 days. There was practically no significance between the service period at different ages, showing that there is no correlation between service period and age. On the whole the data showed that the service period was very high which might be due to sterility and holding off in the herd.

In addition to the general average service period, the mean service period for the years 1904—1913, 1914—1923 and 1924—1934 was calculated separately for different ages and are shown in the table below.

Lactation	Mean (days)	Standard Deviation
(1904—1934) Service period Groups I, II & III together		
1st	215·2972± 8·9515	121·7539± 6·3297
2nd	204·7368± 8·8813	116·1379± 6·2800
3rd	192·1476± 9·3866	114·5775± 6·6373
4th	183·0081±10·5152	116·6190± 7·4354
5th	201·3953±13·7283	127·3108± 9·7073
6th	182·7536±13·6072	113·0310± 9·6219
7th	165·8140±16·7803	110·0364±11·8656
8th	200·0000±28·4090	133·2216±20·0840
9th	180·0000±28·1425	105·2996±19·8997
10th	210·0000±64·1249	143·3876±45·3431
Whole	197·2430± 4·0207	118·3214± 2·8431

Lactation	Mean (days)	Standard Deviation
(1904—1913) Group I (Service Period)		
1st	182·4320±14·7630	89·7998±10·4390
2nd	227·4468±17·8660	122·4822±12·6331
3rd	169·0000±17·0557	107·8700±12·0602
4th	179·6552±23·3090	125·5229±16·4819
5th	195·8333±31·2650	153·1666±22·1076
6th	164·1666±23·6960	116·0862±16·7555
7th	102·3077±20·6286	74·3774±14·5866
8th	203·3334±45·2941	135·8823±32·0277
9th	187·5000±39·4478	111·5755±27·8939
10th	210	— —
Whole	185·1724± 7·8014	118·8276± 5·5164
(1914—1923) Group II (Service period)		
1st	236·8650±13·5108	132·3782± 9·5536
2nd	203·3334±13·0256	110·3817± 9·2105
3rd	209·7402±13·9928	122·7844± 9·8942
4th	205·0000±14·6990	121·2106±10·3937
5th	226·5854±19·8310	126·9803±14·0227
6th	199·2306±21·9685	112·0179±15·5341
7th	207·5000±27·3358	109·3435±19·3293
8th	198·5714±48·7090	128·8720±34·4425
9th	203·3334±78·4108	135·8116±55·4448
10th	310·0000±139·9878	197·8181±98·9090
Whole	215·0476± 6·0261	123·4990± 4·2611
(1924—1934) Group III (Service period)		
1st	198·8461±15·9398	114·9435±11·2711
2nd	180·0000±14·7173	93·0806±10·4067
3rd	178·7500±17·2010	97·3036±12·1630
4th	114·6154± 8·8222	44·9844± 6·2382
5th	158·5714±17·4901	80·1499±12·3674
6th	183·6842±25·9230	112·9956±18·3302
7th	177·1428±32·7508	118·0847±23·1583
8th	196·6667±64·6374	158·3287±45·7055
9th	136·6667±46·6908	80·8708±33·0153
10th	110·0000±40·0000	56·5685±28·2838
Whole	175·4884± 7·0208	102·9422± 4·9643

The above table leads us to the fact that sterility and holding off were more during the years 1914—1923 and that it was decreasing during the last decade.

Best size and shape of plots for experiments on canes.—The yields of Co. 210 from 968 plots of 1/242 acre each 60 ft. × 3 ft. were analysed with a view to determine the following :

(*i*) the best size and shape of plots for experiments on canes and (*ii*) the number of replications necessary in order to get satisfactory results.

The analysis showed that, as would be expected, the error of field experiments is partly governed by size and shape of plots. The percentage variation can be diminished by increasing the plot size up to 1/27th acre. The error is not diminished when we further increase the area. But for the sake of convenience it is desirable to have any area between 1/27 and 1/16th acre. As regards the shape of plots the investigation indicated that the error can be diminished to a slight extent by increasing the ratio of length to breadth upto a limit of thirty. But in practice it is better to adjust the size of plots in such a way as to have the length, five to 10 times the breadth.

The number of replications required depends on the percentage variation; the smaller the variation the fewer the number of replications required and *vice versa*. For land of average variability it is necessary to have 6 to 9 replications.

In the course of the above investigation there was occasion to verify the following remarks of Mr. T. Eden and Dr. R. A. Fisher, *Jour. Agri. Sci.*, Vol. XXIX, pp. 210-231: "The question as to how much soil heterogeneity variance makes its appearance in the one or the other sections into which the analysis of variance is divided depends entirely upon the inter-relation of plot size with block size and the type of soil heterogeneity encountered".

In the case of randomised layouts it was found that efficient and satisfactory results could be obtained by arranging the plots in each block in as compact way as possible. The elimination of error for differences in the fertility of blocks decrease as the number of plots in each block increases. In any layout it seems that it is not advisable to have more than seven or eight treatments at a time. The truth of the above findings is being further investigated with more data.

The distribution of the ratio of the estimated co-efficient of variation in two samples.—The distribution of the ratio of the co-efficient of variation of two samples drawn from the same normal population was investigated and found that if $100v_1$ and $100v_2$ are the estimated percentage variations of two samples, the theoretical value of $\log_e v_1/v_2$ that can arise due to random sampling alone $= z + \frac{1}{2}\log_e \frac{1 + \left(1 - \frac{1}{n_1}\right) v_1^2}{1 + \left(1 - \frac{1}{n_2}\right) v_2^2}$ where n_1 and n_2 are the sizes of the samples and 'z' is Fisher's 'z' distribution given in Table VI of "Statistical Methods for Research Workers". If the observed value of $\log_e v_1/v_2$ is $> z + \frac{1}{2}\log \frac{1 + \left(1 - \frac{1}{n_1}\right) v_1^2}{1 + \left(1 - \frac{1}{n_2}\right) v_2^2}$

the two samples belong to entirely different populations. The above results are valid only if v_1 and v_2 are $< \frac{1}{4}$.

PUBLICATIONS

1. A statistical study of the Body Weight Figures of Special and Ordinary Fed Calves at Pusa, by P. V. Krishna Iyer, *Ind. Jour. of Vet. Sci. & Animal. Hus.*, 5, 1935, 251—265.

2. On some Factors that influence the Error in Field Experiments with special reference to Sugarcane, by Wynne Sayer and P. V. Krishna Iyer (*In the press*).

APPENDIX

TABLE I

Annual statement of Livestock as it stood on the 30th June 1935

Description of cattle	Number of animals from last year	Increase			Decrease					Total
		By birth	By transfer	From Farm	By death	By transfer	By sale	Sent back to Farm	Sent to Pinjrapole	
Bulls for breeding	9	..	8	..	1	..	2	..	..	14
Bulls at New Area	1	..	..	..	..	..	..	..	..	1
Cows—milch herd	51	..	29	..	1	21	2	..	1	55
Cows for breeding	3	..	.	..	..	..	..	..	..	3
Cows for sale	4	..	14	..	1	7	9	..	..	1
Cows—old	2	..	..	..	1	..	..	..	..	1
Cow under observation	1	..	..	..	..	1	..	..	..	..
Cows at New Area	..	..	14	..	5	..	8	..	..	1
Young male stock in dairy	53	27	.	..	5	8	40	..	..	27
Young female stock in dairy	84	34	..	..	10	34	..	..	..	74
Young female stock at New Area	..	1	7	..	..	1	7	..	..	..
Bullocks	9	..	..	4	1	..	..	10	..	2
Total	217	62	72	4	25	72	68	10	1	179
Sheep—male stock	27	5	..	..	6	..	26	..	..	..
Sheep—female stock	50	4	..	..	4	..	50	..	..	..
Total	77	9	..	..	10	..	76	..	..	..

TABLE II

Statement of milk yield for the year 1934-35

Month	Total yield	Average yield per day	Average yield per cow per day	Number of cows			
				Total	In milk	Dry	Percentage in milk
1934							
July . .	23,004	742	20·1	54	37	17	68·5
August . .	23,747	766	20·2	54	38	16	70·4
September .	20,160	672	17·7	55	38	17	69·1
October .	18,526	598	17·1	57	35	22	61·4
November .	15,977	533	17·8	55	30	25	54·4
December .	16,913	546	18·8	59	29	30	49·2
1935							
January . .	19,806	639	20·0	50	32	18	64·0
February .	18,188	650	20·3	52	32	20	61·5
March . .	19,600	632	21·1	51	30	21	58·8
April . .	16,437	548	18·9	51	29	22	56·9
May . .	15,892	513	18·3	54	28	26	51·8
June . .	17,569	586	18·9	55	31	24	56·3
Average . .	18,818	619	19·1	54	32	22	60·0
Average for 1933-34.	23,396	769	18·7	63	41	22	66·2

TABLE III

Lactations of some of the best cows and heifers during 1934-35

Name and No. of cow	Date of birth	No. of calving (in which she gave milk)	Quantity of milk	
			Lb.	Days
Cows				
Laruli 604	20-10-29	2	8,823	304
Chandrika 482	18-12-23	5	8,549	304
Amba 495	28-2-24	7	8,486	304
Makhi 557	14-10-26	5	8,049	306
Chengi 534	11-11-25	4	8,035	306
Muraee 547	25-5-26	5	8,032	304
Brisoorti 609	28-2-30	2	8,009	306
Chakai 563	11-1-27	4	8,001	304
Heifers				
Lachesari 636	23-4-31	1	6,045	306
Biradki 635	16-4-31	1	5,533	302
Dulgi 630	11-1-31	1	5,416	304
Lajmari 638	25-5-31	1	5,312	309
Lachmati 632	28-2-31	1	5,250	306
Lachmohni 644	10-9-31	1	5,191	306

TABLE IV

Statement of cattle disposed off during the year 1934-35

Particulars	No. of cattle	Total price	Average	Average for 1933-34
		Rs. A. P.	Rs. A. P.	Rs. A. P.
Sahiwal cows . .	11	1,715 0 0	159 9 0	131 5 0
„ heifers . .	4	300 0 0	75 0 0	88 12 0
„ bulls . .	2	280 0 0	140 0 0	..
„ young bulls .	17	755 0 0	44 5 0	55 0 0
„ steerlings .	22	700 0 0	31 13 0	..
Total .	56			

	Number of cattle
Sahiwal cows sold at nominal prices	8
„ heifer sold at nominal prices	1
„ cow-calves sold at nominal prices	2
Cross-bred bull calf transferred to Farm	1
Sahiwal cow sent to Pinjrapole	1
	13

TABLE V

Percentage of mortality amongst the pail-fed calves during 1933-34 and 1934-35

Year	Birth	Death	Percentage of mortality
1933-34	68	9	13·2
1934-35	62	15*	24·2

* Including eleven calves died of foot and mouth disease.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST

(F. J. F. SHAW, D. Sc., A. R. C. S., F. L. S., I. A. S.)

(1) BOTANICAL SECTION, PUSA

I. ADMINISTRATION

Dr. F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S., held charge of the Section throughout the year ending June 30, 1935, but his headquarters were transferred to Delhi from 5th November 1934. Dr. B. P. Pal, M.Sc., Ph.D., F.L.S., held the post of Second Economic Botanist.

From the 1st July 1934, to 31st May 1935, Mr. R. D. Bose, Special Research Assistant, officiated as Assistant Economic Botanist. During this period Mr. R. B. Deshpande officiated as Special Research Assistant. With effect from May 24, 1935, Mr. Hukam Singh, Assistant, was transferred to the Botanical Substation, Karnal, *vice* Mr. Kashi Ram, transferred to Delhi to supervise the levelling and lay-out of the new site. Mr. Mohammad Umar and Dr. Swarn Singh were appointed as Assistants on the 1st November 1934 and 18th June 1935 respectively.

Two schemes, one for breeding potatoes for Northern India and another for breeding rust-resistant wheats with the collaboration of Prof. K. C. Mehta of Agra College, both financed by the Imperial Council of Agricultural Research, came into operation in April 1935. Short notes on these schemes which are under the supervision of Dr. Pal, the Second Economic Botanist, are provided separately.

Receipts.—A sum of Rupees (1,348-13-0) one thousand and three hundred and forty-eight and annas thirteen only was realized from the sale of improved seeds, etc., and credited to Government during the financial year ending 31st March 1935.

TRAINING

Post-graduate Training.—Messrs. Sarvayya Chetti, Pushkar Nath, Abdul Aziz, M. P. Bhatnagar, and S. V. A. Hydari completed their post-graduate training during the year and were of material help in the investigations with which they were concerned. On completion of their courses Messrs. Pushkar Nath and Abdul Aziz worked in the Section as honorary research workers from November 1934 to March 1935.

Messrs. P. Krishna Rao, Parlakimedi Scholar from Madras, S. B. Vaidya, King Edward Scholar from the Central Provinces,

S. Z. Hasanain and A. K. Paul, private students from the United Provinces and Bengal, respectively, continued to receive training.

Messrs. R. K. Tandon, and A. K. Mallik from the United Provinces and S. D. Misra from the Central Provinces were admitted this year.

All the post-graduate students were sent to Karnal for a week in March 1935, in order to study the growth and behaviour of crops under irrigated conditions.

As in the previous year, students from the Chemical, Entomological and Agricultural Sections also attended the course of lectures delivered in this Section on Biometry and Statistics during the year.

Dr. J. K. Dubey, Director of Agriculture, Bhopal State, was given special training in plant breeding, Biometry and laboratory technique from November 1934 to February 1935.

Short-Course in Flue-curing Tobacco.—The following ten students were given a special two months' course which consisted of lectures as well as practical training in flue-curing of tobacco :—

1.	U San Maung	(Burma).
2.	Mr. Inam Ahmad . . .	(United Provinces).
3.	,, H. S. Gupta	
4.	,, S. K. Shrivastava . . .	
5.	,, R. Dittamal	(Punjab).
6.	,, P. Gopalaratnam . . .	(Madras).
7.	,, J. K. Banerji . . .	(Bihar and Orissa).
8.	,, L. N. Chowdhry . . .	
9.	,, R. S. Patil	(Baroda State).
10.	,, Sarvottam Rao . . .	(Hyderabad State).

The first eight students were deputed by Provincial Agricultural Departments and the last two by States.

Dairy Students, etc.—Three Dairy Course students, Messrs. Jadhava, Ekambaram, and Perera were given a short course of lectures on plant breeding and field statistics during January, 1935.

Three Assistant Marketing Officers spent a week in this section in February 1935 and were given all possible help in their respective subjects. One Senior Marketing Officer also spent a day in the section.

Season and Rainfall

The total annual rainfall fell below the average for the 25-year period 1906-1930, by 6·32 inches. The month of July received an unusually large share of the total annual precipitation but most of the other months received slightly less rain than the average. The year was remarkable for the unusually high incidence of virus-diseases. The tobacco crop sustained the most severe attack of

"leaf curl" yet recorded in this section, and a field of sann-hemp grown for seed purposes was rendered entirely valueless owing to the attack by a virus disease which almost completely inhibited flowering and seed-setting. Virus diseases were also noted in sesamum, chillies, etc.

A statement of rainfall in the Botanical Section in 1934-35 is given below :

Statement of rainfall in the Botanical Section in 1934-35

Month	Average for 25 years (1906-30)	From 1st June 1934 to 31st May 1935	Difference
	Inches		
June 1934	7·53	6·95	—0·58
July ,,	11·08	16·27	+5·19
August ,,	14·09	8·41	—5·68
September ,,	8·05	4·55	—3·50
October ,,	1·81	2·89	+1·08
November ,,	0·43	0·35	—0·08
December ,,	0·18	0·00	—0·18
January 1935	0·34	0·24	—0·10
February ,,	0·68	0·62	—0·06
March ,,	0·41	0·00	(Traces) —0·41
April ,,	0·56	0·00	,, —0·56
May ,,	1·44	0·00	,, —1·44
Total	46·60	40·28	—6·32

Statement showing the seed distribution in 1934-35 of improved varieties of crops evolved in the Botanical Section, Pusa

Crops	Quantity	Remarks	Crops	Quantity	Remarks
	Lbs. oz.			Lbs. oz.	
Barley Types			***Gram Types***		
Type 1	1 0		Type 2	61 0	
,, 2	10 0		,, 6	66 0	
,, 7	20 0		,, 9	0 2	
,, 10	1 0		,, 17	435 8	
,, 12	1 0		,, 25	568 8	
,, 13	1 0		,, 28	252 0	
,, 14	21 0		,, 53	17 0	
,, 16	1 0		,, 54	17 0	
,, 17	10 0		,, 58	1,076 4	
,, 20	11 0		,, 67	17 0	
,, 21	4,684 0		***Ganja Seed***		
,, 22	14 0		Type 1	123 2	
,, 23	12 0		Mixed	41 0	
,, 24	8 0		***Linseed Types***		
Chillies Types			Type 12	115 2	
			,, 121	153 0	
			,, 124	25 12	
			Hybrid 10	26 0	
Type 34	3 2		,, 21	77 12	
,, 41	0 8		,, 55	115 12	
,, 48	1 0		,, 63	41 0	
,, 51	0 14		,, 68	64 0	

Crops	Quantity	Remarks
	Lbs. ozs.	
Lentil Types		
Type 8	2 0	
,, 11	24 0	
,, 47	6 0	
,, III-54	49 0	
,, III-86	93 0	
Mung Types		
Type 18	12 0	
,, 23	10 0	
,, 31	10 0	
,, 36	12 0	
Oats		
B. S. 1	548 0	
,, 2	106 0	
Hybrid C	86 0	
,, G	37 0	
,, J	69 0	
Patwa Types		
Type 3	51 2	
,, 6	41 3	
New Patwa	44 1	
Paddy Types		
Type 9	6 8	
,, 18	105 0	
,, 24	162 2	
,, 31	166 12	
,, 52	293 0	
Peas Type		
Type 20	256 4	
Potato Varieties		
Pusa white	36 0	
Darjeeling variety	82 0	
Rai seed	2 0	

Crops.	Quantity	Remarks.
	Lbs. ozs.	
Rahar Types		
Type 5	4 8	
,, 15	26 0	
,, 16	21 0	
,, 24	544 0	
,, 51	55 0	
,, 54	44 0	
,, 80	44 10	
,, 82	101 4	
Sarson Seed	2 0	
Safflower Types		
Type 1	30 0	
,, 2	30 0	
,, 3	0 8	
,, 7	32 0	
,, 8	1 0	
,, 14	0 4	
,, 22	1 0	
,, 25	30 0	
,, 30	10 0	
Sesamum Types		
Type 3	6 4	
,, 7	6 4	
Tobacco Types		
Type 28	5 9	
,, 18 (New Rustica)	3 13	
Hybrid 142	2 5	
,, 177	4 3	
Adcock	1 14	
Wheat Types		
Pusa 4	903 4	
,, 12	527 4	
,, 52	4,828 4	
,, 80-5	709 4	
,, 101	1,417 10	
,, 111	581 4	
,, 114	299 12	
,, 122	12 0	
,, 125	12 0	
,, 165	0 2	

II. INVESTIGATIONS

WHEAT (*Triticum vulgare* Host.)

Rust attack and lodging due to strong winds and rain in February were mainly responsible for the fact that only average yields were obtained from wheat fields which promised heavy crops earlier in the season. The highest yielders were Pusa 52 which grown on an area of 0·78 acre yielded 2148·7 lbs. of grain per acre and Pusa 80-5 which grown on an area of 0·34 acre gave an outturn of 1913·5 lbs. of grain per acre. The bushel weights are given in Table I. It will be noted that bushel weights with two exceptions, were higher this year as compared with those for the last year. They were also higher than the average for the last 6 years.

TABLE I

Showing bushel weights of some Pusa wheats

Variety	Weight per bushel in lbs.		
	Average for the past six years ending 1932-33	1933-34	1934-35
Pusa 4	64·23	64·36	64.90
Pusa 12	61·77	59·76	62·60
Pusa 52	64·72	65·67	65.31
Pusa 80-5	..	..	64.50
Pusa 101	..	65.77	65.95
Pusa 111	..	64.58	63.50

Good reports on Pusa wheats were received from various localities. Pusa 4 has been found to be one of the most promising varieties tried in the Nizam's Dominions. Pusa 111, as well as Pusa 80-5 and Pusa 165 have been a success in the United Provinces as is indicated by the Report of the Department of Agriculture in the United Provinces, published in 1935. The Report states "In the trials conducted by Economic Botanist at Raya and Cawnpore, Pusa 165, Pusa 111 and Pusa 80-5 were shown to be of distinct merit over others, Pusa 165 standing best of all". Pusa 114 has continued to be so successful in Sind that the Agricultural Department has issued a leaflet (Agricultural Leaflet No. 38, 1934) entitled "The Advantages of the cultivation of Pusa 114 wheat in Sind". The main advantages to which attention is drawn are the heavy yield, early maturity, rust resistance and high grain quality of this variety. As it is an awned wheat it is especially suitable for cultivation in tracts where there is danger of damage by birds or wild animals.

As mentioned in the last annual report of this Section, two promising hybrids, Pusa 165 and Pusa 120, obtained by crossing the Australian variety Federation with Pusa 4 and Pusa 52, respectively, were tried against the established Pusa wheats and the best wheats bred by the Provinces concerned at a number of stations in the United Provinces and the Punjab in 1933-34. The result was the outstanding success of Pusa 165 which occupied the first three places 14 times out of 18 trials. In the United Provinces and the eastern Punjab to which it appears to be particularly well suited, Pusa 165 has almost invariably outyielded the best local varieties and the established Pusa types. Pusa 120 did not have the same striking success although it did well at a number of places. The trials with these two wheats were also repeated this year but

the results are not yet available. Yield trials with other promising Federation hybrids were carried out for the third year, and, according to the results of their performances, two hybrids have been selected for more extensive tests.

The yield trials of Pusa 52 *versus* a local wheat obtained from the Deputy Director of Agriculture, Muzafferpur, were repeated for the third year in succession, and for the third time again Pusa 52 significantly outyielded the Muzafferpur local variety. The superiority of Pusa 52 having been certainly established, the yield trials will now be discontinued.

As mentioned in Section I of this report, the breeding of rust-resistant wheats for India has been taken up with the collaboration of Dr. K. C. Mehta of Agra College, Agra. A note on this scheme will be found elsewhere.

Barley (*Hordeum vulgare* L.)

Investigations on the mode of inheritance of a number of characters in barley were continued. It has been observed that internal anatomical characters may, like external characters, be controlled by Mendelian factors. Thus in a cross between two Pusa barleys, *viz.*, T. 21 (non-lodging) and T. 1 (lodging), two genetic factors appeared to control the degree of development as well as the distribution and the thickness of the sclerenchyma. This was also confirmed by the behaviour of the F_2 plants in another cross, *viz.*, Cawnpur 251 × Pusa T. 1 ; the latter (T. 1) being the common lodging parent in both crosses. A paper on this subject was read before the Calcutta Session of the Indian Science Congress in January 1935, and has been submitted for publication in the Indian Journal of Agricultural Science.

The nature of mechanical tissue in all the twenty-four types of Pusa barleys was studied. Four kinds of mechanical tissues, depending on the nature and extent of development of the sclerenchyma, were recognized and the Pusa barleys placed within the following categories :—

Mechanical tissue weakly developed (*LODGING*).—Types 1, 3, 4, 5, 15, 17 and 24. (Types 5, 17 and 24, however, have a greater number of layers of sclerenchymatous tissue than T. 1).

Mechanical tissue somewhat better developed than above. Intermediate—A. (*PARTIALLY LODGING*).—Types 10 and 19.

Mechanical tissue fairly well developed. Intermediate—B. (*SLIGHTLY LODGING*).—Types 6, 8, 9, 14 and 18.

Mechanical tissue very well developed. (*NON-LODGING*).—Types 2, 7, 11, 12, 13, 16, 20, 21, 22 and 23.

Striped and virescent plants in barley are being studied and some material has been fixed to study the cytology of albino, striped and virescent plants as well as of branched ears. Traces of both covered and loose smut appeared in T. 21 barley raised from untreated seed and sown about a month later than the usual date, in one particular plot, *viz.*, Barah 4. In other plots, however, only a very few plants of this variety were affected with this disease. The attack of *Helminthosporium sativum* on the 24 types of Pusa barleys was less than that of last year and *H. teres* failed to make its appearance altogether. An investigation carried out at Pusa for the past four years, in collaboration with Dr. Mitra, Assistant Mycologist, Pusa, has shown that environmental factors play a great part in bringing about the disease caused by these two organisms and that the severity of the disease may vary from field to field and even in different parts of the same field. The percentage of leaf area destroyed in the various varieties was determined and the data statistically examined. In both the introduced and in the Pusa varieties of barley, types showing considerable resistance have been noted and promising selections from this view point have been made. A paper on this subject was read before the Indian Science Congress at Calcutta and has been accepted for publication in the Indian Journal of Agricultural Science.

Eight types of Pusa barleys were sent through the Bihar Department of Agriculture to Rothamsted for preliminary malting tests. The cost of the trial is being met by the Imperial Council of Agricultural Research and barleys from different tracts of Bihar have also been sent along with the Pusa types. The results are awaited. These same types will again be despatched to England in 1935-36. The eight types of Pusa barleys sent to Rothamsted last year together with six other types were also sent to the Imperial Agricultural Chemist, Pusa, for a preliminary malting trial and the results obtained will be reported by him.

The various types of Pusa barley have been observed to be attacked, in the seedling stage, by white-ants in different degrees of severity, the amount of damage done being particularly large in the highest yielding variety, *viz.*, T. 21. Seeds and seedlings of this type and of Types 2 and 22 were analysed by the Imperial Agricultural Chemist who found that Types 21 and 22 yielded higher amounts of sugar than Type 2 which is usually attacked the least. Further analysis revealed that the seeds of Type 21 contained the least amounts of ash and silica and it seems possible that the relatively small amount of silica and the consequent softness of the tissues may have rendered seedlings of Type 21 more liable to white-ant attack.

Oats (*Avena sterilis* L. var. *culta* and *Avena sp.*)

The study of inheritance of certain qualitative and quantitative characters was continued. A number of very promising

hybrids have now been secured and will be subjected to yield tests. Of a number of new varieties imported this year from abroad, Fulghum from America, and Belar, Gidgee and Laggan from Australia, show some promise under Pusa conditions. A high degree of sterility, however, was observed in most of the exotic varieties of oats. A study of the average percentage sterility in these as well as in all Pusa oats has been made.

Covered smut is often found in Indian oats and varietal resistance of Pusa oats to this disease has been the subject of an investigation extending over a number of years. A detailed study was undertaken during the year with the collaboration of Dr. Mundkur of the Mycological Section and thirty differentials obtained from Reed in America and eight differentials obtained from Sampson in Wales for the purpose of identifying the physiological strains of the Indian smuts. These samples of oats included a number of species of oats, *viz.*, *A. sativa*, *A. orientalis*, *A. sterilis*, *A. byzantina*, *A. strigosa*, *A. brevis*, *A. nuda*, *A. fatua*, etc. Sixty Pusa types and hybrids and the thirty differentials received from Reed were dehulled and infected with spores of *Ustilago kolleri* collected in the previous year, and were sown in replicated plots. All the types of oats, however, failed to develop covered smut, possibly due to the spores having already lost their viability. Since such spores have been known to remain viable in Great Britain and America for seven years or more the longevity of Indian smut spores is being studied further in the Mycological Section.

A paper on serial experiments with oats was read before the Indian Science Congress.

Paddy (*Oryza sativa* L.)

Preliminary yield trials were carried out with early (autumn) and late (winter) paddies. In the former, four types were tested against one another, and Type 124 and Type 18 were found to be the best. In the late paddy yield trial, eight Pusa types were tested against two selections from Sabour sent by the Paddy Specialist, Bihar and Orissa. The latter varieties, however, did not do very well under Pusa conditions and were very severely attacked by *Helminthosporium*. Among the Pusa types, Type 31 stood first.

Observations on chlorophyll deficient plants were commenced and detailed records of the life-histories of a number of such plants found in the nurseries were kept. An experiment to study tillering in two varieties of paddy with particular reference to the 'critical period of tillering' was initiated and weekly counts of tillering were taken. Both the investigations are being continued.

Maize (*Zea mays* L.)

Cultures were grown from about six hundred samples of cobs which were collected from different parts of India. Attempts were

made to study the morphological and economically important characters of all the cultures. All the cultures were of the flint type and the chief groups as regards seed colour were white, yellow and orange. The cultures differed markedly in characters such as maturity, plant height, cob size, seed size and grain yield. Some cultures appeared promising for grain yield and others for fodder, and all these have been selected for growing next year.

Inbreeding was continued with the strains from the previous year and some crosses were made between the selfed lines.

PIGEON-PEA (*Cajanus indicus* Spreng.)

A paper embodying the results of previous studies on the inheritance of morphological characters and of wilt-resistance in a cross between types 5 and 80 has been written and sent for publication. The mode of inheritance of a number of morphological characters has also been studied in a cross between Pusa Types 5 and 66.

A yield trial with eleven types of Pusa *rahars* was conducted on the Pusa Farm and types 64, 24, and 15 occupied the first three places as regards yield, but the differences between their mean yields were not statistically significant. Some hybrids combining wilt-resistance with erect habit have been fixed and their seed is being multiplied for yield tests.

Indications were obtained on a previous occasion that the severity of wilt (*Fusarium*) attack in pigeon-peas may be greatly retarded if the crop is grown in fields which had been under tobacco in the preceding season. This fact has been substantiated this year by an experiment in which a set of four lysimeters filled with soil from a tobacco field delayed the incidence of wilt to a much longer period than another set of lysimeters filled with soil from an adjacent linseed field. Type 5 *rahar* which is very susceptible to wilt was sown in all the lysimeters and the latter were infected artificially with *Fusarium* spore material. Weekly observations of the number of plants that died due to wilt during the period were maintained from the fourth to the thirty-first week after infection. Although most of the plants died in both the series owing to very heavy artificial wilt-infection of the soil, plants in the tobacco soil series took on an average $21 \cdot 187 \pm 0 \cdot 348$ weeks to die out, whereas those in the linseed soil series died in $17 \cdot 548 \pm 0 \cdot 504$ weeks. The difference of $3 \cdot 639$ weeks between the two series being statistically significant it was concluded that the toxic effect of tobacco stumps in the tobacco soil series helped to retard deaths due to wilt to a considerably longer period. It is possible that under ordinary conditions the rotation of pigeon-pea with tobacco may considerably lessen damage due to wilt.

GRAM (*Cicer arietinum* L.)

The yield trial of eight types was repeated, and Type 53 and Type 58 occupied the first two places this year. It has now been

proved that the new types Nos. 53, 55 and 58 are definitely high yielders and worthy of trial on outside farms with the old established types Nos. 3, 17 and 25.

The progenies of two " stray " plants found last year in the types were studied. These were found to be segregating. In the progeny of the " stray " plant found in Type 79 (itself a mutant) it was interesting to find segregation to the ordinary and the gigantic form (like Type 79), the latter behaving as a simple recessive character.

PEAS (*Pisum sativum* L. and *P. arvense* L.)

The yield trial of five types was repeated and the *sativum* variety Type 29 found to be the best yielder as in the past two years.

Final observations on the types were made. The classification and description of these types is in preparation.

LENTILS (*Ervum lens* L.)

Six hybrid lentils were again tried this year against two very high yielding selections in a 8 × 8 Latin square. This experiment will be repeated once again and final results computed on the basis of the combined results of three years. The study of the inheritance of flower and seed colours in a number of crosses has been completed.

URID AND MUNG (*Phaseolus Mungo* L. and *P. radiatus* L.).

Preliminary yield trials with promising types of *urid* and *mung* were conducted. The mode of inheritance of a number of characters was studied in a cross between a green-seeded and a yellow-seeded *mung*. The results will be tabulated and written up for publication at an early date.

SUNN-HEMP (*Crotalaria juncea* L.)

Notes on morphological and economically important characters of single plant cultures were taken. A large number of these cultures were raised from single plant seed collected from different parts of Bengal and work has been started in collaboration with the Assistant Fibre Expert, in charge of the Fibre Section, Dacca, with the object of evolving strains of sunn-hemp suitable for Bengal.

A virulent virus disease attacked the sunn-hemp crop grown for seed purposes and later on spread to other single plant cultures which were grown away from the former. The different cultures, however, showed varying degrees of susceptibility to the disease.

A study of the root system of sunn-hemp has been made and the results agree very closely with those obtained in the previous year.

Indian hemp (*Cannabis sativa* L.)

Three strains of Indian hemp (*ganja*) have finally been isolated. Types 1 and 2 are good for *ganja* production, the former giving high yields and the latter producing drug of a superior quality. Type 3, on the other hand, is a tall growing strain, not suitable for *ganja* production and is being maintained only because it throws out the least number of monoecious plants and may thus be of some use in sex-studies. A quantity of *ganja* (about 123 lbs.) was cured and sold to the Excise Department, Bihar and Orissa. A smoking test was held by the Superintendent of Excise, Patna, who reports that veteran smokers were invited to smoke *ganja* obtained from Bhagalpur as well as that from Pusa and the smokers who were independently questioned spoke highly of the intoxicating effects of the Pusa *ganja* as compared to the Bhagalpur product. The Chemical Examiner for Excise, Bihar and Orissa, Patna, obtained the following analytical values for the mixed *ganja* sold to that Department.

	Per cent
Ash	14·9
Resin	12·0

"The sample of *ganja* is of fair quality. The physiological activity is about 3/4."

Three samples of *ganja* were also sent to the Imperial Agricultural Chemist, Pusa, for analyses and the following results were kindly furnished by him :—

Lab. No. of 1935	Particulars of sample	Extraction by carbon tetrachloride		Extraction by petroleum ether		Ash
		Specific rotation	Resin	Specific rotation	Resin	
			Per cent		Per cent	Per cent
87	Pusa Ganja, Cured Type 1-2.	—137·03	13·60	—143·28	11·76	17·3
88	Pusa Ganja, Cured Type 2-2.	—174·10	15·05	—203·80	13·56	15·3
89	Pusa Ganja, Cured Type 1 mixed.	—157·43	14·80	—148·17	13·44	15·1

Tobacco (*Nicotiana tabacum* L. and *N. rustica* L.)

At least 50 per cent of the plants of Hybrid 142 cigarette tobacco grown for flue-curing were affected by "leaf-curl" disease. This high incidence, however, was favourable for the study of the disease

which has been taken up with the collaboration of the Entomological Section.

Seed of Hybrid 142, Adcock and Harrison's Special was raised in large quantities for supply to the Provinces in connection with a co-operative scheme, financed by the Imperial Council of Agricultural Research, to determine what areas in India are suitable for the cultivation and curing of cigarette tobacco.

A few hybrid plants obtained from a cross between *N. tabacum* and *N. plumbaginifolia* are under study.

Potato (*Solanum tuberosum* L.)

Work on this crop was begun in the year under review and the collection and study of material from different parts of India and from abroad was undertaken. The Imperial Council of Agricultural Research has approved of a scheme whereby potato breeding for Northern India will be carried out at Pusa (and subsequently at Delhi) and at a sub-station in the hills. A note on this scheme has been prepared by the Second Economic Botanist who is in charge of the scheme and appears elsewhere.

Chilli (*Capsicum annuum* L. and *C. frutescens* L.)

The original fifty-two types were maintained. Some of the types of chillies from Goa which were found to be still segregating were discarded as well as those which were not promising from an economic point of view.

The F_1 of a cross between Type 1 and Type 2 was grown to study the inheritance of colour of unripe fruit which is green in the former and creamy in the latter. In F_1 the unripe fruit is green which indicates dominance of this colur over creamy. The F_2 of Type 29 × Type 11 and the F_2 of Type 3 × Type 11A were studied for the inheritance of anther colour. The yellow colour of anthers of Type 11A was found to be recessive to the deep purple and light purple anther colour of Types 3 and 29, respectively on a 3 : 1 basis. It was also observed that purple colour in anthers is linked with purple node colour in both Type 3 and Type 29.

Hibiscus (*Hibiscus sabdariffa* L. and *H. cannabinus* L.)

The F_2's of the crosses between varieties Albus and Ruber and between Ruber and New Hibiscus were grown to study the effect of time of fertilisation of F_1 plants on the phenotypic segregation in F_2. Populations of about 12,000 in the case of the former cross and about 22,000 in the case of the latter were grown. The results did not indicate that the age of F_1 plants has any influence on the phenotypic segregation in F_2. The results, therefore, confirm the observations of the previous year when the populations studied were comparatively much smaller.

A cross between two very early varieties of *H. cannabinus* L. one with white corolla and the other with yellow corolla was made and the F_1 grown the same year. The corolla in F_1 was yellow indicating its dominance over white.

The F_2 of a cross between an early, short variety and a late, tall variety of *H. cannabinus* L. was grown to study the inheritance of (*a*) number of days required for flowering and (*b*) height of plant. The results indicate that probably a number of cumulative factors determine each of the characters. The F_3 is expected to throw more light on this. The original types were maintained.

Linseed (*Linum usitatissimum* L.)

In connection with the attempt to breed out flower colour factors a very large F_2 population of the cross between a white and a pink flowered variety was grown with the expectation of realizing a genotype in which all colour (petal) factors would be absent and which could be used as a "tester". About 200 single plants from the phenotype with white petals and white anthers in F_2 were each crossed with four different types of known genetic constitution. The progenies out of these crosses are expected to indicate if any of these 200 plants lack all the colour factors. The seed colour of these 200 plants is either brown, fawn, grey or yellow and as some of the seed colour factors also influence petal colour, the elimination of plants with certain seed colours is expected to facilitate the isolation of the desired genotype.

The F_3 generations of two crosses, Type 12 × Type 24 and Type 21 × Type 24, confirmed the dihybrid segregations for petal colour observed in F_2, and the study is expected to elucidate the genetic constitution of Type 24.

The F_1 generations of crosses between rust-resistant and rust-susceptible types were grown. No trace of rust was observed on the F_1s while the rust-susceptible parents and other adjoining cultures were attacked indicating dominance of rust-resistance over susceptibility to rust.

Yield trials of seven hybrids against the standard type 12 were repeated for the third time. Type 12 has consistently proved superior in yield to all the hybrids except Hybrid 21 and Hybrid 55 in one year when it was equal to these hybrids. Hybrid 55 which fared well in the two previous years went down in yield very much and Hybrid 68 took its place. It seems that in dry years and in tracts of low rainfall Hybrid 68 out-yields Hybrid 55 probably because of its earlier maturity. The reports of yield trials conducted by some of the Provincial Agricultural Departments also show Hybrid 68 to be very promising.

Retting experiments with ordinary linseeds were carried out and a sample of fibre of Type 124 was sent to the Imperial Institute, London, for opinion. The preliminary tests indicate that

the fibre though coarse may find a good market in England. Large quantities of the fibre, however, are required for detailed tests and as it is not possible to supply these the investigation will unfortunately have to be dropped. The interesting fact remains, however, that the ordinary linseed is capable of yielding good fibre.

The seed-weight and size (volume) of all the types and hybrids of linseed were determined. There is indication that a negative correlation subsists between seed size and oil percentage, this being contrary to the general belief that the larger the seed the higher the oil content. While trying to correlate seed size and oil percentage a few other interesting points were discovered. Thus seeds of the brown seeded hybrids were found to be, on the whole, the heaviest and largest, and contained the lowest oil percentage. Next came the gray seeded hybrids, closely followed by the fawn seeded ones. The yellow seeded hybrids were, on the whole, the lightest and the smallest in size but possessed the highest oil-content. The oil-content, therefore, appears to increase with increasing lightness of seed colour as well as with decrease in seed size. The data are being further analysed.

Safflower (*Carthamus tinctorius* L.)

The various types were maintained. The F_1 of a cross between Type 27 and a chlorotic mutant disclosed the normal green condition to be dominant to the chlorotic condition.

The F_2's of a number of crosses were studied for the inheritance of flower colour, spininess and bract-shape.

White flower was found to be recessive to yellow or orange flower on a 3 : 1 basis. The spineless character was found to be recessive to its allelomorph on a 15 : 1 basis and roundish shape of bract recessive to elongate shape on a 3 : 1 ratio.

Sesamum (*Sesamum indicum* DC.)

Owing to heavy rains at sowing time germination was rather poor but growth was more vigorous than in the preceding year.

The influence of time of sowing on yield was studied and it was discovered that the earlier sown series heavily out-yielded the later-sown series. Certain F_1's from crosses between the Pusa types of sesamum were studied to see whether there is any hybrid vigour in this crop.

Phyllody, which assumes serious proportions in certain years causing loss in yield owing to decreased seed-setting in phylloid plants, was also under investigation, and the data so far obtained indicate that it is probably of the nature of a virus disease.

BRASSICAE

Observations on the types were made and the tentative classifications of the different groups finally checked. A paper on this subject is being written up for publication.

A type of *rai* (*B. juncea*, Hooker) with lyrate leaves and other kinds of *rai* with non-lyrate leaves were crossed last year to study how these kinds of *rai* are related to each other. The F_1 generations of these crosses were grown this year and almost all crosses were found to have been successful and showed a marked degree of hybrid vigour. Observations on different morphological characters were recorded on these hybrids.

The F_2 families of a cross between two types of *rai* were studied for pod habit and last year's results with F_2 populations confirmed.

The F_2 families of a cross between two types of yellow *sarson* (*B. campestris* var. Sarson, Prain) were also studied for flower colour and number of pod valves.

The inheritance of self fertility was studied in the F_4 families of a cross between yellow sarson (self-fertile) and black sarson (self-sterile). The mode of inheritance of this character appears to be very complex.

Statement of yield of crops in the Botanical Section, Pusa, during 1934-35

Crop	Plot	Area in acres	Outturn of Grain in pounds		Remarks
			Actual	Per acre	
Wheat—					
P. 4 .	Orch. 3-A . .	0·55	550·8	1,001·5	Sown very late without manure.
P. 12 .	N. T. G. 3 . .	0·36	566·2	1,572·8	No manure.
P. 52 .	Pentagonal . .	4·22	7,239·6	1,715·5	Ferm. cake 50 Mds.
P. 52 .	Mush. Out No. 2 .	0·20	325·0	1,625·0	Ferm. cake 2 Mds.
P. 52 .	Mush. Out No. 3 .	0·20	337·9	1,689·5	Ferm. cake 2 Mds.
P. 52 .	N. T. G. 10 . .	0·78	1,676·0	2,148·7	Ferm. cake 15 Mds.
P. 80-5 .	Lawn 3 . . .	0·34	650·6	1,913·5	Ferm. cake 8 Mds.
P. 101 .	N. T. G. 10 . .	1·0	1,820·0	1,820·0	Ferm. cake 20 Mds.
P. 111 .	Orch. 3-B . .	0·54	475·2	880·0	Sown very late, without manure.

Crop	Plot	Area in acres	Outturn of grain in pounds		Remarks
			Actual	Per acre	
Barley—					
Type 21	River bank west .	0·74	2,575·6	3,480·5	Manured with Ferm. cake 8 Mds.
,, .	Orch. 4-A . .	0·65	1,375·2	2,115·7	No manure.
,, .	Barah 4 . . .	0·75	1,769·1	2,358·8	Sown late after removing sesamum crop.
,, .	Mush. Out No. 5 .	0·20	485·5	2,427·5	Sown late after removing Urid crop. No manure.
Oats—					
B. S. 1 .	Farm 1 . . .	0·43	643·9	1,497·4	No manure.
B. S. 2 .	Farm 1 . . .	0·42	497·8	1,185·2	No manure.
Hybrid C	River bank east .	0·38	927·8	2,441·6	Manured with ferm. cake 4 Mds.
Hybrid J	River bank east .	0·38	1,055·3	2,777·1	Manured with ferm. cake 4 Mds.
Hybrid G	N. T. G. 1 . .	0·21	436·1	2,076 7	No manure.
Paddy—					
T. 9 .	Gonhri border . .	0·05	40·1	802·3	
T. 18 .	,, Plot No. 1 .	0·16	366·2	2,287·5	
T. 24 .	,, ,, 2 .	0·16	323·0	2,018·6	
T. 24 .	,, ,, 11 .	0·16	298·3	1,864·3	
T. 31 .	,, Triangular plot	0·53	972·0	1,494·3	
T. 52 .	,, Plot No. 3 .	0·16	298·3	1,864·3	
T. 52 .	,, ,, 10 .	0·16	240·7	1,504·3	
Lentils—					
III-86 .	S. T. G. 1 . .	0·02	20·6	1,030·0	No manure.
,, .	,, 7 . . .	0·04	47·3	1,182·5	,,
,, .	,, 9 . . .	0·05	45·3	906·0	,,
Ganja (Indian hemp)—					
Type 1 .	Barah 5 . . .	0·47	142·9	304·0	Manured with 20 srs. Ammon. sulphate.
,, 2 .	N. T. G. 4 . .	0·08	42·1	526·2	Manured with 10 srs. Ammon. phos. and F. Y. manure 5 carts.
			Yield of drug in lbs.		
Cured Ganja	,, 4 . . .	0·25	123·45	493·8	
Linseed—					
T. 12 .	Barah 2 and 3 parts .	0·15	138·7	918·7	
T. 12 .	Pent. E. border .	0·11	80·2	729·1	
T. 124 .	Mush. out No. 1 .	0·20	111·6	558·0	
T. 121 .	Pent. W. . . .	0·13	126·0	969·2	
H. 55 .	Mush. out No. 4 .	0·20	67·9	339·5	
Safflower—					
T. 30 .	Barah 7 and 8 parts .	0·10	50·4	504·0	

Crop	Plot	Area in acres	Outturn of grain in pounds		Remarks
			Actual	Per acre	
Gram—					
T. 2	Orch. 6 B part	0·17	133·7	786·5	
T. 6	„ „	0·20	308·6	1,543·0	
T. 17	„ 6 A part	0·78	1,388·6	1,780·3	
T. 25	„ „	0·78	1,197·3	1,535·0	
T. 28	„ 6 B part	0·25	425·8	1,703·2	
T. 58	„ „	0·80	1,845·2	2,306·6	
Peas—					
S. 14-1	S. T. G. 5	0·16	186·10	1,163·1	

Statement showing the outturn of improved varieties of crop from the Botanical Section grown at the Pusa Farm during 1934-35

Crop	Plot	Area in acres	Outturn of Grain in pounds	
			Actual	Per acre
Barley—				
T. 21	3, 4, 7, 8, 11, 12, 15, 16 Punjab D Block	2·00	2,037·60	1,018·80
T. 21	North Pangarbi	5·75	12,054·80	2,096·49
Oats—				
B. S. 2	Brickfield 2	2·00	1,992·80	996·40
Hybrid J	„	6·00	5,428·80	904·80
„ C	„	3·00	1,890·50	630·17
Rahar—				
T. 15	Bhugrason	5·00	6,128·20	1,025·60
T. 24	„	9·00	11,139·50	1,237·70
T. 51	„	9·10	7,792·50	855·10
T. 80	„	4·40	3,404·60	773·77
Safflower—				
T. 1	28 D, Punjab D Block	·0625	70·40	1,126·40
T. 2	„ „ „	·0625	45·80	732·80
T. 3	„ „ „	·0625	40·10	641·60
T. 4	„ „ „	·0625	61·20	979·20
Hibiscus (Patwa)—				
Type 3	Nepali	·50	52·40	104·80
„ 6	„	·50	83·30	166·60
New Patwa seed	„	·10	29·80	298·00
„ fibre	„	·50	59·70	119·40

III. PUBLICATIONS AND PROGRAMME OF WORK FOR 1935-36

List of papers published during 1934-35

1.	Kashi Ram and Ch. V. Sarvayya Chetty . . .	The Classification of Rices of Bihar and Orissa. *Ind. Jour. Agri. Sci.*, Vol. IV, pt. IV, 1934, pp. 618-641.
2.	———————————	Development of Pigments in the Glumes and Apiculus of Rice Varieties. *Ind. Jour. Agri. Sci.*, Vol. IV, pt. IV, 1934, pp. 642-655.
3.	Pal, B. P.	Recent Progress in Plant Breeding at Pusa. *Agri. and Livestock*, Vol. IV, pt. V, 1934, pp. 505-515.
4.	———	Wheat Rusts from the view point of Plant Breeding (Paper read at the Symposium on Cereal Rusts at a Joint meeting of the Botanical and Agricultural Sections of the Indian Science Congress, Calcutta, Jany. 1935). *Agri. and Livestock in Ind.*, Vol. V, pt. II, 1935, pp. 139-144.
5	Shaw, F. J. F. and Kashi Ram	Improved Varieties of Crops Produced at Pusa. *Agri. and Livestock in India*, Vol. IV, pt. V, 1934, pp. 465-480.
6.	Shaw, F. J. F. . . .	Indian Agriculture and Plant Breeding. (Presidential Address to the Agricultural Section of the Indian Science Congress, Calcutta, Jany. 1935, pp 109-114).

Programme of work for 1935-36

Work will be continued on the breeding and genetics of those crops which have formed the subject of this report. Special attention will be given to yield trials and statistical methods.

Training of students will continue as in past years.

(2) BOTANICAL SUB-STATION, KARNAL

I. INTRODUCTION

Mr. Kashi Ram held the post of Superintendent up to May 24, 1935, when he reverted to the post of Assistant Economic Botanist, Imperial Institute of Agricultural Research, Delhi. Mr. Hukam Singh, Assistant to the Imperial Economic Botanist, Pusa, took charge from May 25, 1935.

Rulya Ram, Head Mali, was transferred to the "Lay Out" section of the Imperial Institute of Agricultural Research, Delhi. Thaggan, Assistant Mali, Botanical Section, Pusa, was appointed to officiate in place of Rulya Ram from May 23, 1935. Tale Ram, Watchman, was also transferred to the "Lay Out" Section, Delhi.

During this year the following amounts were realised, principally by the sale of seeds :—

	Rs.	A.	P.
(1) Cash credited into Karnal Treasury . . .	1,770	7	0
(2) Receipts adjusted by Book Transfer . . .	388	7	6
Total .	2,158	14	6

Lay-out and construction

A block of about 18 acres, in the General Area was levelled in the last cold weather. Another block of about 20 acres will be taken up for levelling during the ensuing year. The levelling of roads in the General Area was continued and two more roads have been levelled. Some more roads, however, still remain to be levelled up.

The following areas have been fenced with Hercules woven wire fencing :—

(1) Building area.

(2) Experimental area.

(3) Rice area.

Training

A batch of eight post-graduate students from the Botanical and Agricultural Sections, Pusa, visited the Sub-station in March 1935 to observe farming and plant breeding under irrigated conditions. Students from the Agricultural College, Lyallpur, were also shown the work in progress at the Sub-station.

Visitors

Mr. Ramdhan Singh, Cerealist to Government, Punjab, and Mr. Nand Singh, Extra Assistant Director of Agriculture, Karnal, visited the Sub-station in March 1935.

Mr. Livingstone, Agricultural Marketing Adviser to the Government of India and Mr. Javarayya, Senior Marketing Officer, visited the Sub-station in April 1935.

Season and Rainfall

The season was characterised by heavy downpours in the months of July and August followed by a drought in September. Continuous cloudy weather with intermittent showers in April was very favourable for black rust which caused much damage to wheat.

Statement showing the rainfall at the Botanical Sub-station, Karnal, in 1934-35

Months	Rainfall inches	Number of cloudy days in the month
1934		
July	16·98	26
August	9·97	30
September	0·43	11
October	..	..
November	..	5
December	0·26	18
1935		
January	2·76	16
February	1·35	13
March	0·54	15
April	1·47	14
May	..	6
June	.	13
Total	33·76	167

II. INVESTIGATIONS

Wheat (*Triticum vulgare* Host.)

As indicated in last year's annual report wheat hybrids P. 165 and P. 120 were subjected to extensive field tests in the Punjab and United Provinces against the well-known Pusa wheats and also the best wheats evolved by the Provinces concerned. The results obtained were statistically analysed and showed that in P. 165 we possess a wheat of distinct merit. Out of 18 yield trials, it stood first in 2 trials (the difference between P. 165 and the next best being statistically significant on four occasions), second in 3 cases and third in 3 cases. In the United Provinces and South East of Punjab it out-yielded the best local wheats and the established Pusa wheats. Pusa 120 did not, however, have the same success, perhaps owing to its grain-shedding character which reduces the final yield. Both hybrids 120 and 165 are characterised by good stand and comparative resistance to rusts.

These varietal trials have been repeated in the year under report in the Punjab and United Provinces. So far, the results from only

one station in the Punjab, Jullundur, where P. 165 again out-yielded the other wheats in the trial, giving a significantly higher yield than P. 120, P. 114, P. 111, P. 112, P. 80-5, Punjab 8-A and Punjab C. 409, both under irrigated and non-irrigated conditions, have been received. In the yield trial conducted this year at this Sub-station also P. 165 has proved to be superior to P. 120, P. 80-5, P. 114, Cawnpore 13, Punjab C. 591 and Punjab C. 518, the difference in yield between it and the other wheats mentioned being statistically significant. The full results are given in Table I.

Table I

Wheat yield trial (Varietal)

Comparison of wheats Pusa 80-5, 114, 120, 165, Cawnpore 13, and Punjab C. 518 and C. 591

Plan and yields of grain in lbs. per plot

C. 13 37·50	P. 114 40·75	P. 120 38·37	P. 80-5 44·31	P. 165 62·00	C. 518 44·81	C. 591 38·94	P. 114 42·19	C. 13 34·19	P. 120 35·00	C. 518 33·37	P. 80-5 39·12	P. 165 58·44	C. 591 36·12
P. 80-5 52·44	C. 591 41·31	P. 165 60·00	C. 518 37·06	P. 114 43·25	P. 120 49·69	C. 13 39·56	C. 518 49·81	P. 165 53·06	P. 80-5 43·25	P. 114 40·37	C. 591 36·00	C. 13 34·00	P. 120 40·69
C. 518 50·56	C. 13 37·87	P. 120 53·31	P. 165 61·19	C. 591 35·81	P. 80-5 50·25	P. 114 44·25	C. 518 43·94	P. 120 43·56	P. 165 59·12	C. 13 36·25	C. 591 39·25	P. 114 42·19	P. 80-5 ·31
P. 114 42·81	C. 591 45·81	C. 518 50·44	P. 120 50·62	C. 13 40·81	P. 165 59·00	P. 80-5 52.94	C. 13 36·19	P. 165 61·62	P. 114 45·00	C. 518 37·75	P. 80-5 47·00	P. 120 ·50	·591 ·06
C. 518 42·81	P. 80-5 56·25	C. 13 38·94	P. 165 59·06	C. 591 31·62	P. 114 40·56	P. 120 42·50	C. 591 36·31	P. 80-5 43·25	P. 120 48·50	C. 13 37·12	P. 114 44·87	518 ·62	P. 165 55·75
P. 120 52·00	C. 518 50·56	P. 165 60·12	P. 114 44·75	C. 13 33·44	C. 591 38·00	P. 80-5 47·75	P. 165 57·12	C. 518 41·75	C. 13 37·50	P. 80-5 47·87	P. 114 46·75	P. 120 47·25	C. 591 44·94

System of replication—Randomized blocks (7 varieties and 12 replications).

Area of each plot—56′ × 14′ = 1/55-56th of an acre.

Seed sown on—4th November 1934.

Harvested on—17th April 1935.

Previous crop—Gram.

Summary of results (Grain)

	Mean yields in lbs.							General mean	Standard error of treatment mean	Whether general effect of treatment is significant by 'Z' test	Critical difference for significance in lbs. per acre
	P. 165	P. 120	P. 114	P. 80-5	Cawnpore 13	Punjab C. 591	Punjab C. 518				
Per acre	3270·82	2532·42	2396·86	2656·32	2052·94	2139·61	2470·20	2502·74	60·15	Significant	218·96196
Per cent. on General Mean.	130·69	101·19	95·78	106·14	82·03	85·50	93·71	100·00	..	..	

(1) P. 165 superior to P. 120, P. 80-5, P. 114, C. 518, C. 591, C. 13.

(2) P. 80-5=P. 120=C. 518 but superior to P. 114, C. 591 and C. 13.

(3) P. 120=C. 518=P. 114 but superior to C. 591 and C. 13.

(4) C. 518=P. 114 but superior to C. 591 and C. 13.

(5) P. 114 superior to C. 591 and C. 13.

(6) C. 591=C. 13.

The differences are significant at 1 per cent level.

In addition to P. 120 and P. 165, other hybrids have also been selected and it is intended to give them a preliminary yield trial during the following year. The hybrids from the cross between Pusa 52 and Federation which were previously known as 13-1, 23-1, 52-1, and 61-1-2 are now numbered as P. 121, P. 123, P. 126 and P. 116, respectively. Of these P. 126 is very late. All these wheats are non-shedding, possess good standing power, and are relatively rust resistant.

As mentioned in the last year's annual report the experiment on wheat bunt was repeated by the Imperial Mycologist and the results are published in the Indian Journal of Agricultural Science (Vol. V, part I, pp. 51-74).

Seed Treatment

All the wheat seed of the last year as well as from this year's crop was treated against loose smut. Last year, two methods, solar heat treatment and the orthodox hot water treatment were employed but as the former was not so successful as the latter all the seed has been treated this year by the hot water method. In this connection, the help rendered by the Mycological Section at Pusa is gratefully acknowledged.

BARLEY (*Hordeum vulgare* L.)

A few new samples of barleys were grown along with selections from the crosses made at Pusa. Selections in these cultures have been made on the basis of good stand, white colour of grain, etc., and will be grown during the next year for further study.

Barley types 4, 13, 16, 18, 21 were again tried in a yield trial against Lyallpur types 4 and 5 in a 7×7 Latin Square. The results of this yield trial are given in Table II.

TABLE II

Barley yield trials (Varietal)

Comparison of Pusa types 13, 18, 4, 21 and 16 and Lyallpur types 4 and 5.

Plan and yield in lbs. per plot.

T. 13 48·81	L. 5 55·94	T. 18 46·56	T. 4 37·62	L. 4 29·81	T. 21 55·44	T. 16 52·19
L. 4 42·44	T. 13 51·00	L. 5 60·06	T. 18 44·31	T. 16 54·81	T. 4 35·44	T. 21 58·94
T. 18 58·12	T. 4 48·69	T. 21 69·81	L. 4 37·94	T. 13 51·00	T. 16 61·44	L. 5 61·94
T. 21 60·06	T. 18 50·19	T. 4 45·06	T. 16 62·44	L. 5 58·44	L. 4 44·06	T. 13 61·94
L. 5 51·81	T. 16 60·00	T. 13 53·56	T. 21 67·19	T. 4 44·62	T. 18 51·31	L. 4 42·00
T. 16 43·94	T. 21 59·44	L. 4 42·81	T. 13 53·56	T. 18 46·81	L. 5 54·94	T. 4 41·81
T. 4 34·56	L. 4 37·31	T. 16 36·56	L. 5 44·81	T. 21 54·44	T. 13 49·31	T. 18 46·81

System of replication—Latin Squares (7 varieties and 7 replications).

Area of each working plot—49′ × 15′—1/59·26 of an acre.

Sown on—30th October 1934.

Harvested on—4th April 1935.

Previous crop—Gram.

Summary of Results (Grain)

—	Mean yield in lbs.							General mean	Standard error of treatment mean	Whether general effect of treatment is significant by "Z" test	Critical difference for significance in lbs. per acre
	T. 13	L. 5	T. 18	T. 4	L. 4	T. 21	T. 16				
Per acre .	3125·37	3284·19	2913·22	2436·18	2339·58	3685·38	3143·74	2989·67	102·3124	Significant	397·63 at 1 per cent level
Per cent on General mean.	104·54	109·85	97·44	81·48	78·26	123·27	105·15	100	..	..	..

Type 21>L. 5=T. 16=T. 13=T. 18>T. 4=L. 4.

Oats (*Avena sterilis* L. var. *culta*, etc.)

1·74 acres of the improved types were grown for multiplication. The yield of this crop has been shown in the outturn statement appended at the end.

Paddy (*Oryza sativa* L.)

The classification of types of rice isolated from samples collected from parts of the United Provinces and the Punjab has been completed. Forty-two types in all have been isolated and a paper on this subject has been written up for publication in the *Indian Journal of Agricultural Science*. The climatic conditions in these parts, unlike those in Bengal and Bihar, do not favour the cultivation of late maturing paddy varieties. The onset of cold in the month of November has an adverse effect on grain-setting and grain-filling. The early rices, therefore, predominate.

The classification of the types has been based on the morphological characters of grain, glumes, etc. The main divisions are based on the chemical constitution of the rice kernal, presence and absence of clustering in spikelets and length of the outer glume. After this the colour of the inner glume has been taken as the most suitable criterion. The inner glume exhibits a wide range of easily distinguishable colours and affords a ready and convenient means of discrimination. Next to the colour of the inner glume, the colour of the apiculus is the most important criterion. This colour is either restricted to the extreme tip or is spreading. After the apiculus the colour of the outer glumes is used, then the colour of the kernal and internodes and finally the grain size and shape which are the most constant among the quantitative characters, have been used in separating the ultimate classes.

Since this work is in continuation of the classification carried out at Pusa where 123 types have been isolated, the 42 types isolated at Karnal have been numbered from 124 to 165.

Types 125 and 130 are very promising. These types were tested last year against Pusa Type 97 and Pusa Type 60 paddies in a randomized block lay-out. It is evident from the results given below in Table III that these types have out-yielded the rest, the difference being statistically significant Both these types possess somewhat long and slender grains, and stand out well in the field. The yield trial is being repeated again in the next season.

TABLE III

Paddy yield trial (Varietal)

Comparison of Paddy types K. 50, K. 102, K. 137, K. 151, P. 60 and P. 97

Plan and yield in lbs. per plot

K. 50 49·00	K. 151 41·75	K. 102 27·75	P. 60 21·00	K. 137 45·75	P. 97 48·38	K. 137 47·25	K. 151 44·25	P. 60 22·25	P. 97 44·25	K. 102 37·25	K. 50 47·75
K. 151 41·75	K. 102 25·63	K. 137 47·25	K. 50 42·75	P. 97 48·38	P. 60 18·13	P. 60 22·00	K. 50 42·75	K. 151 44·38	K. 102 33·25	P. 97 37·75	K. 137 48·25
P. 60 22·50	K. 137 50·00	K. 151 39·00	P. 97 44·50	K. 102 25·63	K. 50 48·50	K. 102 28·50	K. 137 48·80	P. 97 45·63	P. 60 18·25	K. 50 44·50	K. 151 41·00

System of replication—Randomized blocks (6 varieties and 6 replications).

Area of each working plot—40′ × 14′— (1/77·78 acre).

Transplantation date—20th July 1934.

Harvesting date—25th October 1934.

Previous crop—Paddy.

Summary of Results (Grain)

	Mean yield in lbs.						General mean	Standard error of difference	Significance of "Z" test	Critical difference for significance in lbs. per acre
	K. 50	K. 102	K. 137	K. 151	P. 97	P. 60				
(1) Per acre	3568·15	2307·73	3724·88	3238·31	3425·32	1632·60	2993·75	139·08	Significant	38·763 at 1 per cent level
(2) Percentage on general mean.	119·18	77·08	124·49	108·17	116·42	54·53	100	..	..	..

(1) K. 137=K. 50=P. 97 but superior to K. 151, K. 102 and P. 60.

(2) K. 50=P. 97=K. 151 but superior to K. 102 and P. 60.

(3) P. 97=K. 151 but superior to K. 102 and P. 60.

(4) K. 151 superior to K. 102 and P. 60.

(5) K. 102 superior to P. 60.

The differences are significant at 1 per cent level

GRAM (*Cicer arietinum* L.)

All the 24 Pusa types of gram as well as the following crosses were grown :—

(1) Cross T. 35×T. 2	. . . . .	F_2 generation
T. 2×T. 35	. . . . .	Do.
(2) Cross T. 39×T. 2	. . . . .	Do.
T. 2×T. 39	. . . . .	Do.

Unfortunately all these were severely attacked by *Rhizoctonia*. The damage done in certain types was more than in others but the crosses in particular suffered heavily, with the result that very few plants survived. An attempt will be made to repeat the crosses next year.

Last year a stray plant with simple leaves but similar to T. 17 in flower colour and character was detected in gram type 17. The seeds of this plant were sown during this year. Out of thirteen plants produced, ten were like the stray plant possessing simple leaves while the remaining three were like T. 17, having compound leaves. The character of simple leaves, therefore, appears to be dominant over that of compound leaves.

Grams T. 17, T. 25, T. 48, T. 58, T 67 and the local variety were tested for yield in randomized blocks. The results are given below in Table IV.

TABLE IV

Gram yield trials (varietal)

Comparison of Gram Pusa types 17, 25, 46, 58, 67 and Karnal local gram

Plan and yield in lbs. per plot

T. 25 32·87	T. 58 50·81	T. 46 44·19	Local 64·87	T. 17 50·56	T. 67 45·69	T. 17 52·12	T. 58 57·50	T. 25 65·94	Local 58·81	T. 67 26·69	T. 46 68·00
T. 46 52·25	T. 26 55·81	Local 58·81	T. 67 45·81	T. 17 57·69	T. 58 61·87	T. 46 61·19	Local 58·47	T. 17 53·94	T. 67 54·31	T. 58 63·75	T. 25 70·37
T. 58 39·62	T. 67 54·81	T. 46 53·94	T. 25 66·31	Local 61·37	T. 17 62·56	T. 58 58·81	T. 67 39·00	Local 65·75	T. 25 71·50	T. 17 65·69	T. 46 67·19
T. 17 52·81	T. 25 57·81	T. 67 58·62	T. 58 64·87	T. 46 70·94	Local 73·31	Local 69·31	T. 58 73·56	T. 46 77·50	T. 67 63·69	T. 25 76·81	T. 17 67 25

System of replication—Randomized blocks (6 varieties and 8 replications).

Area of each working plot—84′ × 16′—(1/32.41 acres).

Sown on—6th October 1934.

Harvested on—10th April 1935.

Previous crop—Wheat.

Summary of results (grain)

	Mean yield in lbs.						General mean	Standard error of treatment mean	Whether general effect of treatment is significant by "Z" test	Critical difference for significance in lbs. per acre
	T. 25	T. 58	T. 46	Local	T. 17	T. 67				
Per acre . .	2015·25	1988·35	2006·18	2060·30	1874·27	1574·48	1919·805	87·52644	Significant	318·27 at 1 per cent
Percentage on general mean.	104·98	103·57	104·50	107·32	97·63	82·002	100	..	..	..

(1) Local Type 25, Type 46, Type 58, Type 17.

(2) Local Type 25, Type 46, Type 58> Type 67 at 1 and 5 per cent levels.

(3) Type 17 <Type 67 at 5 per cent level.

PEAS (*Pisum sativum* L. and *P. arvense* L.)

The variety 14-1 (T. 29) selected at Pusa was grown on a field scale, without supports this year. The yield of grain obtained was 2,355 lbs. per acre. Thus this type which is a dwarf garden variety possessing large wrinkled seeds, does well at Karnal also.

Seed multiplication of improved Pusa types of crops

A large portion of the area of the Sub-station was under the following improved varieties of crops which are in constant demand.

Crop	Variety	Area sown in acres	Crop	Variety	Area sown in acres
Wheat . .	P. 4 .	9·89			
	P. 12 .	4·63	Paddy . .	Type 125	0·63
	P. 12-2 .	1·14		,, 129	0·65
	P. 80-5 .	14·58		,, 130	0·64
	P. 111 .	10·38		Pusa 97	0·65
	P. 114 .	6·78		,, 60	0·75
	P. 120 .	2·55		,, 52	0·40
	P. 165 .	6·43		,, 24	0·75
Gram . .	Type 17	3·36	Linseed . .	Type 12	3·18
	,, 25	5·01			
	,, 58	5·29		,, 121	
Oats . .	Hybrids C. G. J. & B. S. 2.	1·74		,, 124 Hybrids 10, 21, 55, 68 and flax	
Peas . .	14-1 .	1·17			

III. SEED DEMAND AND DISTRIBUTION.

The demand for improved seed is increasing year by year and in many cases the seed indents had to be refused or could only be partially fulfilled. During the current year there was a big demand for wheat types, P. 4, P. 12, P. 80-5 and P. 114, and all the available seed has been booked up for supply. Similarly there was a large demand for seeds of gram types 17 and 25 but this could not be met as the quantity available for distribution was far too short of the demand. The seed distribution during the year is shown in the following statement :—

Statement of seed distributed during the year 1934-35

Variety	Quantity in lbs.
Wheat—	
P. 4	4237·7
P. 12	3560·2
P. 80-5	11089·3
P. 111	4241·9
P. 112	57·6

Variety	Quantity in lbs.
P. 114	4640·9
P. 120	3474·5
P. 165	3071·3
Gram—	
T. 58	15634·3
T. 17	1974·9
Oats—	
Hybrid G	82·3
„ J	4032·2

IV. STATEMENT SHOWING THE CROP RETURNS OF THE BOTANICAL SUB-STATION, KARNAL FOR 1934-35

Area	Plot No	Crop	Area in acres	Actual yield in lbs.	Calculated outturn per acre in lbs.
General	6 to 8	Gram T. 17	3·36	3949·7	1175·50
	13 to 16	„ T. 25	5·29	11190·9	2115·48
	9 to 12	„ T. 58	5·01	7868·5	1570·55
	20 to 23	Wheat P. 4	9·69	10306·3	1063·60
	1 to 5	„ P. 12	4·63	5348·6	1155·20
	43 to 51	„ P. 80-5	14·58	23081·2	1583·07
	24 to 28	„ P. 111	10·38	10789·8	1039·48
	17 to 19	„ P. 114	6·78	7843·8	1156·90
	30 to 34	„ P. 165	6·27	6829·7	1089·26
	29	Oats B. S. 2	0·35	676·8	1933·71
		„ C	0·35	808·5	2310·00
		„ G	0·35	880·5	2515·71
		„ J	0·69	1750·6	2537·10
	42	Linseed T. 12	0·75	824·9	1099·87
		„ T. 121	0·50	580·1	1160·20
		„ T. 124	0·75	660·4	880·53
		„ H. 10	0·25	201·6	806·40
		„ H. 21	0·25	228·3	913·20
		„ H. 55	0·25	207·8	831·20
		„ H. 68	0·25	265·4	1061·60
		Flax	0·18	82·3	457·22
Experimental	10	Wheat P. 12-2	1·14	1919·3	1683·59
	15 & 16	„ P. 120	2·55	4696·5	1841·76
	2	Peas 14-1	1·17	2748·3	2348·97
	1	Sann-hemp	1·09	1472·9	1351·30
Paddy	1	Paddy T. 125	0·63	1351·5	2145·24
		„ T. 127	0·65	1127·3	1734·31
		„ T. 130	0·64	1814·4	2835·00
		„ T. 164	0·92	1431·8	1556·30
		„ P. 97	0·65	1872·0	2880·00
		„ P. 60	0·75	946·3	1261·73
Building area.	1	Wheat P. 165	0·41	1149·9	2304·65

(3) SCHEME FOR BREEDING RUST-RESISTANT WHEATS

[B. P. Pal, M.Sc., Ph.D. (Cantab.), F.L.S.]

The scheme which is financed by the Imperial Council of Agricultural Research provides for the breeding of rust-resistant wheat at the Botanical Section, Pusa, and at a Sub-station at Simla. The work is being carried out in collaboration with Dr. K. C. Mehta the results of whose investigations on wheat rusts in India are being utilised in drawing up the breeding programme.

The scheme officially commenced on the 7th April 1935 when Mr. M. A. Aziz, B.Sc. (Agri.), was appointed Wheat Breeding Assistant with headquarters at Simla, but actually work was started last October when wheats to be used as parents for making crosses were sown both at Pusa and at Simla. The series of crosses mentioned in the original scheme has been successfully made as well as a large number of other crosses which it was thought might prove of value for breeding purposes. The full list is given below :

List of wheat crosses made at Simla during 1934-35.

Serial No.	Cross	Number of grains obtained	
		(Direct)	(Reciprocal)
1	Vernal × Khapli	8	17
2	Khapli × Kota	11	2
3	„ × Reliance	8	15
4	„ × Chinese White	8	12
5	„ × T. sphaerococcum	3	..
6	„ × P. 4	5	3
7	„ × P. 12	9	..
8	„ × P. 114	2	..
9	„ × P. 165	7	2
10	„ × C. 518	21	2
11	Kota × Reliance	3	..
12	„ × April Bearded	17	7
13	„ × Chinese White	4	..
14	„ × P. 114	10	..
15	„ × C. 518	7	1
16	Reliance × Chinese White	14	14
17	„ × April Bearded	5	10
18	„ × P. 114	32	12
19	„ × C. 518	9	11
20	T. sphaerococcum × Chinese White	1	19
21	„ × P. 52	1	4
22	„ × P. 4	2	5
23	„ × P. 12	1	2

Serial No.	Cross	Number of grains obtained	
		(Direct)	(Reciprocal)
24	Chinese White × P. 4	10	13
25	,, × P. 12	9	19
26	,, × P. 80-5	7	10
27	April Bearded × Red Marvel	19	14
28	,, × Square Head's Master	32	4
29	,, × Chinese White	9	..
30	Red Marvel × Square Head's Master	17	21
31	Square Head's Master × P. 52	10	22
32	Mediterranean × Karsten's V	5	14
33	,, × Spalding's Prolific	15	12
34	,, × April Bearded	3	..
35	,, × P. 4	13	..
36	,, × P. 12	48	7
37	,, × P. 52	8	..
38	,, × P. 80 5	17	..
39	,, × P. 114	12	1
40	,, × P. 165	20	26
41	,, × C. 518	8	18
42	Karsten's V × Democrat	17	20
43	,, × Pusa 4	16	3
44	,, × Pusa 80-5	15	7
45	,, × Pusa 101	25	3
46	,, × Pusa 111	25	..
47	,, × Pusa 114	21	2
48	,, × Pusa 165	42	10
49	,, × C. 518	31	..
50	Spalding's Prolific × Democrat	24	13
51	,, × Pusa 4	23	1
52	,, × Pusa 52	10	13
53	,, × Pusa 80-5	14	14
54	,, × Pusa 114	15	13
55	,, × Pusa 165	45	9
56	Democrat × Pusa 4	4	..
57	,, × Pusa 80-5	28	..
58	,, × Pusa 52	13	..
59	,, × Pusa 165	10	..
60	,, × C. 518	14	..
61	Pusa 4 × April Bearded	1	..
62	,, × Yeoman II	9	..
63	,, × Iron	4	..
64	Pusa 12 × April Bearded	1	..
65	,, × Karsten's V	3	..
66	,, × Spalding's Prolific	4	..
67	Pusa 52 × Khapli	9	..
68	,, × Chinese White	4	..
69	,, × Karsten's V	15	..

Serial No.	Cross	Number of grains obtained (Direct)	Number of grains obtained (Reciprocal)
70	Pusa 80-5 × T. sphaerococcum	3	..
71	,, × Khapli	1	..
72	,, × Red Marvel	11	..
73	,, × April Bearded	8	..
74	,, × Pusa 114	10	..
75	Pusa 114 × Karsten's V	3	..
76	,, × Square Head's Master	6	..
77	,, × Chinese White	4	..
78	,, × April Bearded	5	..
79	,, × Pusa 80-5	8	..
80	,, × Pusa 111	10	..
81	,, × Pusa 165	13	..
82	,, × Yeoman II	1	..
83	,, × T. sphaerococcum	5	..
84	Pusa 101 × T. sphaerococcum	9	..
85	,, × Chinese White	3	..
86	,, × Spalding's Prolific	4	..
87	,, × Little Joss	12	..
88	,, × Iron	6	..
89	,, × Khapli	4	..
90	,, × Rivet (Cambridge)	5	19
91	Pusa 111 × April Bearded	4	..
92	,, × Chinese White	10	..
93	,, × Khapli	1	..
94	,, × Pusa 114	10	..
95	,, × Spalding's Prolific	8	..
96	,, × Iron	3	..
97	Pusa 165 × T. sphaerococcum	2	..
98	,, × Rivet	15	4
99	,, × Chinese White	16	..
100	,, × April Bearded	3	..
101	,, × Square Head's Master	7	..
102	,, × Red Marvel	1	..
103	,, × Iron	2	16
104	,, × Yeoman II	11	8
105	,, × Pusa 114	13	..
106	,, × C. 518	7	..
107	C. 518 × T. sphaerococcum	13	..
108	,, × Chinese White	15	..
109	,, × Pusa 111	6	..
110	,, × Pusa 114	6	..
111	Pusa 101 × Yeoman II	16	..
112	Little Joss × Pusa 165	6	..

The F_1 generations of all these crosses will be grown and studied at Simla this winter.

14 SCHEME FOR POTATO BREEDING IN NORTHERN INDIA

[B. P. Pal, M.Sc., Ph.D. (Cantab.), F.L.S.]

This scheme whereby the breeding of improved varieties of potatoes is to be undertaken at Pusa (and subsequently Delhi) and at a substation in the hills, the latter financed by the Imperial Council of Agricultural Research, came into operation on the 1st April 1935.

Mr. Pushkar Nath, M.Sc. (Hons.), was appointed Assistant-in-charge of the substation, with temporary headquarters at Simla, and K. Pathak, a First Grade Mali from the Botanical Section, Pusa, was temporarily transferred to Simla to officiate as Fieldman. Pending the final selection of a site for the substation, accommodation at the Rust Research Laboratory, "Flowerdale", Simla E., was kindly provided by Dr. K. C. Mehta, and a small temporary staff was recruited to assist the Assistant-in-charge.

To determine the most suitable site for potato breeding work, a standard set of potato varieties has been grown at six hill-stations, namely, Simla, Murree, Kulu, Chaubattia, Ramgarh and Shillong by arrangement with the Directors of Agriculture of the Provinces concerned. Detailed notes on flowering and berry formation are being taken and the selection of the site for the substation will be based on the information collected.

Attention is being concentrated at present on the collection and study of potato material from different parts of India and from abroad. This work was commenced at Pusa last year and already a fair amount of material has been collected and is now growing at Simla.

REPORT OF THE SUGARCANE EXPERT

(Rao Bahadur T. S. Venkatraman, B.A., I.A.S.)

I. CHARGE AND STAFF

I held charge of the Office of the Government Sugarcane Expert throughout the year except for 14 days leave on average pay during July 1934 when the Second Cane Breeding Officer, Mr. N. L. Dutt, M.Sc., held charge. The Second Cane Breeding Officer was on leave for 28 days in May 1935 when his Senior Botany Assistant—Mr. M. K. Krishnaswami, M.A.—held charge of the post in addition to his own duties.

II. SUGARCANE BREEDING.* (MAINLY SUB-TROPICAL TYPES)

(*a*) Breeding technique

The breeding technique during the year was more or less the same as in previous years. The raising of seedlings and hardening them for long journeys by rail to Experimental Stations in North India are tending to become annual routine. Certain of the selections made in North Indian Stations from such material have shown promise of usefulness. The modified method of topping canes with the object of influencing their time of flowering, mentioned in the previous report, gave disappointing result.

The quality of water used in irrigating seedlings during the early nursery stages appears to be an important factor for proper stand and growth. Certain of the crosses, particularly the intergeneric ones, are intolerant to water containing salts; and the presence of organic matter in irrigation water appears to conduce to vigorous growth. The importance that has been attached to vigour of growth in recent years has appreciably raised the standard of selections made.

(*b*) The breeding programme

(*i*) *Parents.*—The search for useful parents was continued and resulted in two additions, *viz.*, Co. 331 and Co. 508. Co. 331 is useful for introducing both vigour and good habit and Co. 508 for introducing early high sucrose.

* The breeding of tropical types is detailed in the report of the Second Cane Breeding Officer. (Section IX).

(*ii*) *Inbreeding.*—The programme of inbreeding carried on with Co. 214 has proved useful in yielding seedlings as immune to mosaic as Co. 214 itself and others giving high early sucrose in juice, another prominent character of Co. 214.

(*iii*) *Cross pollinations made.*—The preceding drought shifted somewhat the relative times of flowering of the parents, with the result that cross pollinations, difficult or not possible in previous years, were done with considerable ease during the year. One such was Co. 349×Co. 313, a combination intended mainly for Shahjahanpur in the United Provinces.

During the year thirty experimental crosses were made, to get ideas about the type of seedlings produced. Five crosses —which as experimental crosses had shown promise of usefulness in previous years—were made on a mass scale, the mother parents employed being Co. 213 and Co. 349 and the pollen parents Co. 244, Co. 285, Co. 312 and Co. 313.

(*c*) DESCRIPTIONS OF NEW SEEDLINGS

It has been the practice to describe from time to time, and in some detail, new Coimbatore canes as they prove useful in cultivation. Description of seven such canes have already been published; a second batch of seven was thus described during the year by Mr. S. A. Hussainy. These were studied in all the important Sugarcane Testing Stations in India.

III. CYTO-GENETICAL STUDIES

Cyto-genetical studies in sugarcane are a recent development, perhaps the most notable contribution so far being from Java. While some cytological work has been in progress at the station from about 1932, it was thought desirable to extend the same by employing a whole time Geneticist and this was rendered possible through funds kindly sanctioned by the Imperial Council of Agricultural Research. Dr. Miss E. K. Janaki Ammal, M.A., M.Sc., D.Sc., F.L.S., worked as Geneticist throughout the year.

The cytology of the different types of *Saccharum spontaneum* —of which a fair collection is available at the station—was one of the first subjects to receive attention. It would appear probable that the primitive forms of *S. spontaneum* are those with a relatively low number of chromosomes and certain of these forms occur in India. The Dacca form—which is the nearest to *Saccharum officinarum* in morphological characters—possesses the same number of chromosomes as both *S. officinarum* and *S. robustum* Jeswiet (the vigorous wild form collected from New Guinea). Evidence from chromosome numbers and behaviour indicate hybridity within the species. The results are being written up for publication.

The inter-specific crosses studied during the year included Vellai×*S. Narenga*, Vellai×*S. spontaneum* and P. O. J 2725×

various types of *S. spontaneum*. A careful examination was made of the intergeneric hybrids with *Sorghum*. A search for definite characteristics in the morphology of *Sorghum* chromosomes revealed two chromosomes with trabants in *Sorghum Durra* Stapf. *Sorghum Versicolor* and *Sorghum halepense* showed 10 and 40 chromosomes respectively and *Saccharum arundinaceum* 40 chromosomes.

Many controlled crosses were made for obtaining reliable material for cytogenetical work in the genus *Saccharum*. The necessary artificial emasculation presented considerable difficulties on account of the smallness of the flowers, but the work has yielded a certain amount of material. Controlled crosses were made using Vellai, *Gigas* and Kassoer as the female parent and *Sorghum Durra* Stapf as pollen parent. The reciprocal crosses with *Sorghum* as female parent proved unsuccessful. A certain number of interesting back crosses were effected between *Sorghum* hybrids and *Sorghum*, Co. 205 and *Saccharum spontaneum*, and *Kassoer* ×*Glagah*.

Various improvements in technique were effected both in field cross pollination and in the laboratory. An attempt to induce somatic mutations in cane by various forms of bud mutilations and topping the plants yielded certain abnormal buds, but callus formation—as was to be expected—was rare. This work will be continued in subsequent years.

IV. RESEARCH

(*a*) Types of Saccharum spontaneum

The collection of *Saccharum spontaneum* from Bihar by Mr. R. Thomas in 1933 is proving of rather unusual interest. Besides wide differences in morphological characters, the types collected show interesting variations both in depth and method of branching of roots. One of the types analysed gave as high as 13 per cent sucrose in juice and yet another would appear to represent a form intermediate between *Saccharum spontaneum* and *S. arundinaceum*. This incidental exploration of just a portion of Bihar is indicative of possibilities if and when other portions of the country are systematically explored for wild forms of *Saccharum*.

Seed viability tests showed that certain of the Indian forms retained viability longer than those from Burma or the Eastern Archipelago.

(*b*) Mosaic incidence

Aphis maidis rarely colonises freely on sugarcanes at the station not even on the susceptible kinds. Preliminary experiments by Mr. R. Thomas showed, however, that they do colonise more freely when the plants are grown in an etiolated condition by cutting off light. A rough inverse correlation was noticed between

the degree of resistance and the ease with which the insects colonise on the different canes under study. The colonies soon died on shoots of Co. 214 and Co. 335—two seedlings known to be immune —but lived for sometime on the susceptible canes. The work will be continued as it might ultimately lead to the development of a technique for picking out canes resistant or immune to mosaic.

Help was given to the Government Mycologist at Coimbatore for germinating sugarcane seeds and tending them during their early stages to ascertain if mosaic is transmitted through seed. The results are reported to have negatived such transmission.

(c) Sugarcane×Sorghum hybrids

Certain of these hybrids which were continuously back-crossed with *Sorghum* yielded seedlings which, in their floral structures, approach closer to *Sorghum Durra* Stapf. This was particularly noticeable in the size of fruit and callus hairs and the awn in the fourth glume. The cane Vellai was successfully crossed with various types of *Sorghum* and *Erianthus* for cytological studies.

(d) Cane germination

Studies on cane germination indicated that material from arrowed canes was inferior to that from non-arrowed ones in that they took longer to germinate. Standing canes, topped in the field sometimes before use as planting material, showed quicker and better germination. This method might be of some use in experimental stations, at least, for maintaining a satisfactory stand in the plots. Attempts to correlate ash content with germination did not give any definite indications.

(e) Arrowing in Sugarcanes

Arrowing—at any rate under Coimbatore conditions—was again found to be not an indication of ripeness. The arrowed canes of the same variety were found to be distinctly superior to the non-arrowed canes for about two months after arrowing and in all respects, including weight and juice quality. The arrowing of sugarcanes at the station is mainly during October—November After that period, while a steady improvement is noticed in the non-arrowed canes till April, the arrowed ones show but little improvement. The results are being written up for publication.

V. DISTRIBUTIONS FROM THE STATION

(a) As true Seed

Seeds of Co. 349×Co. 212 ♂ and Co. 349×Co. 313 ♂ were preserved and sent to the Economic Botanist at Shahjahanpur and of *Saccharum robustum* to Mauritius for germinating at the two places.

(*b*) As Seedlings

Five thousand seedlings of Co. 213 crossed with Co. 285 and Co. 244 were sent to the Sub-station, Karnal and about an equal number of Co. 349 crossed with Co. 312 and Co. 313 to the Sugarcane Research Station at Shahjahanpur, by railway in through wagons after hardening them for the journey. Work at both the above stations is financed by the Imperial Council of Agricultural Research.

(*c*) As Canes

About 200 packets containing over sixty varieties, mostly Co.'s, were distributed to 90 places within the limits of India. Twenty-seven packets were sent to Natal, Durban, Gold Coast, Kumasi, Formosa, United States of America and Iran.

VI. PERFORMANCE OF COIMBATORE CANES

(*a*) Coimbatore canes in India

The marked feature during the year has been the good opinion earned by the thick type of Co. canes bred by the Second Cane Breeding Officer, Mr. N. L. Dutt, M.Sc. Of the many thick types under test in various experiment stations, Co. 419 is easily the most outstanding for tropical conditions. It has shown better growth than the "wonder cane" of Java—P. O. J. 2878—in certain parts of tropical India. Very good preliminary reports have also been received about the performance of Co. 421 from more than one station in Northern India. It is likely to take a definite place in the future as a semi-irrigated cane.

The more recent Coimbatore seedlings are steadily finding a place in subtropical India as further improvements over the Coimbatore types already popular there. One such is Co. 331 which combines both vigour and good habit and promises to be useful as a late season cane. Another such is Co. 312 which, though not satisfactory in habit, gives high yields and resists summer conditions.

Quite recently there has been a big expansion of sugarcane area in the tract commanded by the Nizamsagar canal in Hyderabad. Co. 213 is reported to have been largely responsible for this expansion. Owing to the light nature of the soil, cane growing used to be costly because of wooden props which had to be used to prevent lodging; Co. 213 through its excellent habit does not require such supports and besides requires less water.

(*b*) Coimbatore canes in foreign countries

The canes produced at Coimbatore are receiving increased recognition in many foreign countries particularly because of their greater resistance to diseases and pests and the comparatively less favourable conditions under which they are able to thrive.

Co. 281 has proved resistant to "Streak" in South Africa and to "pine apple" disease in Porto Rico. Co. 290 has proved resistant to many diseases including the "gumming" disease in Australia. Co. 213 has shown utility on low lands in Cuba overrun with grass and is a favourite in Brazil.

VII. PARENTAGE OF COIMBATORE SEEDLINGS

Co. 432	P. O. J. 2727 × Co. 285.
Co. 433	P. O. J. 2878 General collection. (Likely father E. K. 28).
Co. 434	
Co. 435	Co. 363 × P. O. J. 2727.
Co. 436	Co. 364 × [Kassoer × B. H. 10 (12)].
Co. 437	Co. 408 × Co. 415.
Co. 438	
Co. 517	Co. 290 × Co. 335 (Co. 214 self).
Co. 518	Co. 214 self.
Co. 519	Co. 290 × Co. 313.

VIII. THE KARNAL SUBSTATION

(*a*) Growth conditions during the year

The summer during the crop season was of the usual severity in the tract though severer than in the previous season. The rainfall (33·09") was a trifle more than the average of 29" to 30" but the distribution was agriculturally less useful. The frost was severer than usual and continuous. The crop under study experienced four continuous frosty nights against the fewer and more disconnected frosty nights recorded for the three previous crops. This killed a considerable portion of the crop in South East Punjab and West United Provinces and led to a great demand for seed from the cane growers. Of the four crops raised at the Substation so far, the last suffered the most from two serious pests of the tract—*viz.*, Pyrilla and Top Borer. This afforded a good opportunity to study their relative incidence on the different canes under test.

(*b*) Seedlings under test from their Early Nursery Stage

Five thousand and eight hundred such seedlings, composed of equal numbers of Co. 213 × Co. 285 and Co. 213 × Co. 244, were grown during the year. These ultimately yielded fifty-five preliminary selections, five of which were superior in juice quality to Co. 285—the now popular cane in the Punjab and promising to be so in West United Provinces. One hundred and twenty-six seedlings selected as above from the previous-year-lot and grown during the year in rows for further selection gave twenty-two types.

Besides the above, 6,500 seedlings in the nursery stage were imported from Coimbatore during the year. The crop of seedling

canes at the Sub-station thus represented over 17,000 new seedlings grown at Karnal from the nursery stage and now in different stages of trial.

(c) STUDIES OF SEEDLING CANES IN REGULAR TEST PLOTS

The number of seedlings which were selected for detailed study during the year was forty two. It is found it takes generally three years for a new seedling, grown at Karnal from the nursery stage, to reach this status. The studies were on the same lines as in previous years with slight improvements in technique.

(1) *Resistance to adverse conditions*

(*i*) *Summer drought.*—The summer during the year which was fairly severe showed the undermentioned canes to be resistant to summer conditions in descending order. This conclusion was arrived at by the methods described in previous reports.

Co. 312, Co. 290, Co. 285, Co. 356, Co. 313 and Co. 331. Co. 244 and Co. 213 were found to be distinctly inferior to the above in this respect.

(*ii*) *Frost.*—Frost during the year was comparatively severe and continued for a fairly long period. Root systems of sugar-canes vary in their depth at different periods of their life cycle. A correlation was indicated between the depth of roots at time of frost incidence and frost resistance. Of the eleven varieties, whose roots were six feet deep a little before frost, 82 per cent escaped with slight injury and 18 per cent were moderately affected. On the other hand, of the thirteen varieties whose roots were only three feet deep at the time, 61·6 per cent escaped injury and 15·3 per cent were moderately and 23·1 per cent seriously affected.

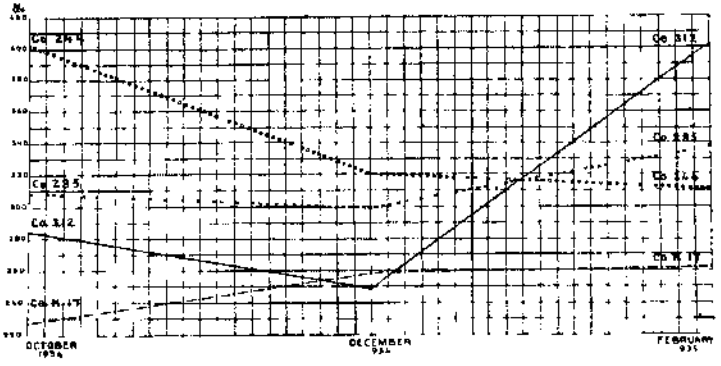
It was also noticed that lodged canes were more affected than unlodged canes of the same variety thus emphasizing the value of good habit for sub-tropical conditions.

(*iii*) *Insect pests.*—All the forty two varieties in the test plots were periodically examined for degree of attack from Pyrilla and Top Borer, the two dominant pests during the year. The Government Entomologist, Punjab, to whom my grateful thanks are due, gave all possible advice and help in studying relative incidence. Recently, he has kindly transferred the Headquarters of his Assistant from Sonepet to Karnal and I have promised him facilities at the Sub-station.

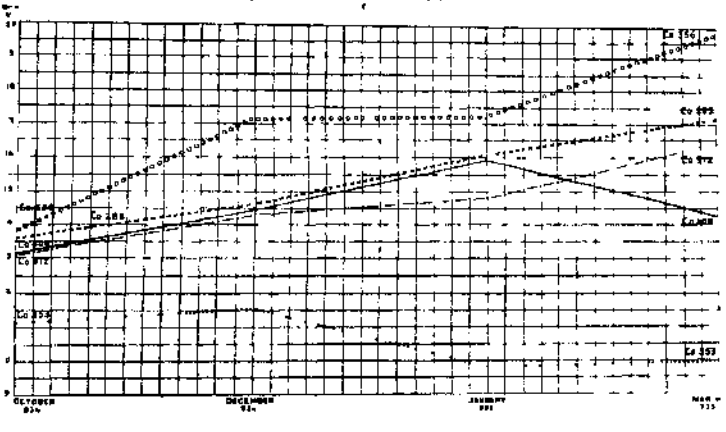
Pyrilla.—This was found on all the canes, none being altogether immune. Co. 285 and Co. 408 were least affected and Co. 312 and Co. 356 among those moderately affected.

Top Borer.—The Assistant to the Government Entomologist, Punjab, kindly examined the crop and favoured me with figures indicating the degree of incidence. It is satisfactory that Co. 331 —a promising cane of the future—is relatively resistant.

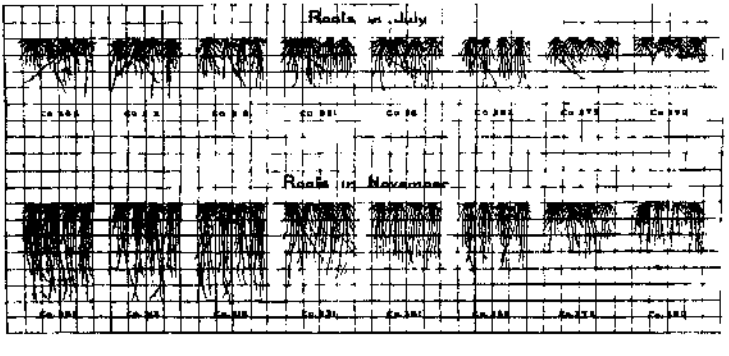
Periodic weights of millable canes
(Karnal 1934-35 crop)



Brix Readings
(Karnal 1934-35 crop)



Root Dissections
Karnal 1935



(*iv*) *Lodging from high winds and cyclones.*—The monsoon period at Karnal is often followed by high winds which not infrequently develop into cyclones. The nature of soil is such that it gets sodden after rains or heavy irrigation, and gives little hold for the cane roots and facilitates lodging. Even under such conditions Co. 331, Co. 205, Co. 213, Co. 313, Co. 318 and Co. 341 showed practically no lodging; canes like Co. 244, Co. 312 and Co. 290, on the other hand, lodged badly, the first being the worst in this respect. As lodging, besides rendering the canes more liable to frost, injuriously affects juice quality on account of the shooting of buds; this is a major draw-back in canes intended for this tract.

(2) *Life cycle of the canes under test*

(*i*) *Cane yields.*—The quantity of millable canes obtained per acre is an important factor in determining harvest yields be it gur or white sugar. Periodic weighments of millable canes of ten rows each 20 feet long at each observation yielded some useful data. The manner in which each variety builds up its cane tonnage is important as this, combined with the periodical juice analyses, is useful in determining the most profitable time for harvesting the different varieties. Periodic weights of four such canes are graphed in Plate III, Fig. 1. It will be noticed that, whereas both Co. K. 17 and Co. 285 show a steady increase in weight of canes, Co. 244 shows an appreciable drop from October, apparently resulting from certain of its canes getting spoiled or killed by lodging and frost. Co. 312 is obviously best harvested late in the season as it builds up considerably in cane weight after December. These results confirm the finding in the previous year's report that in certain varieties canes die during the crushing season and are thus lost for harvest.

(*ii*) *Juice quality.*—An ideal cane, particularly for the small scale Indian grower, would be one which, after reaching satisfactory juice quality early in the season, either maintains it or improves as the season advances. Other canes, whose period of optimum juice quality is comparatively short, necessitate their crushing during a shorter period for securing the best results. This is a disadvantage where for a variety of reasons—including rains at the time—the harvest operations of the small grower are dependent on outside environmental factors. Plate III, Figure 2 gives the periodic Brix readings of three popular canes—Co. 312, Co. 285 and Co. 213—in contrast with two others which have been rejected for this and other reasons. To obtain samples for the above analyses a whole row (20 feet long) was cut and milled, rejecting such shoots as showed no cane formation.

(*iii*) *Root dissections.*—A positive correlation has already been indicated between root depth at time of frost incidence and resistance of the variety to frost damage. A deeply developed root

system particularly at the critical periods is a great advantage. Periodic dissections in situ (Plate III, Fig. 3) have shown Co. 312, Co. 285, Co. 318 and Co. 331 to be satisfactory in this respect. They show a deep root system both in July and in December. The other seedlings figures are relatively unsatisfactory.

(3) *Results of studies—Co. 285 a safe cane*

The above studies have indicated Co. 285 as the most useful all-round cane for the tract. Its gur is slightly coloured; but on account of its resistance to adverse conditions like drought, frost and Pyrilla attack it is the safest cane to grow. The promising canes include Co. 312, Co. 313, Co. 244, and Co. 331. The last named has excellent agricultural characters and might have a definite use as a late-season cane.

(*d*) Barani Trials

Water being an important and sometimes a costly factor in cane growing, a plot had been laid from the very commencement of the Sub-station to try and select canes which would grow under Karnal conditions without any artificial irrigation. Periodic weighments, root dissections and juice analyses showed that Co. 205 was the best and next Co. 285. Other canes which showed some use from this view point were Co. 326, Co. 341, Co. 318 and Co. 321 in descending order. More canes from the main plots were taken to this area based on their performance during the year.

IX. REPORT OF THE SECOND CANE BREEDING OFFICER

(N. L. Dutt, M.Sc.)

(*a*) Sugarcane Breeding (Mainly Tropical Types)

(1) *Crossing Operations.*—An extensive breeding programme was gone through involving as many as 100 combinations. Experience gained from last year's experimental crosses was utilized in giving definite orientation to crossing in certain directions, particularly with regard to the use of Co. 419 and Co. 421 as parents. These two canes besides yielding seedlings of desirable type give very satisfactory germinations of seeds—an important factor in thick cane breeding. The utility of certain other canes as parents was investigated, but their experimental crosses will need to be repeated for another season or two, before finally deciding about their merits.

(2) *Nursery Seedlings.*—Over 1,50,000 seedlings were germinated in seed pans and about half the number transplanted into beds. Finally about 14,000 seedlings were grown in the field plots for the full year tests. In the field the seedlings from the various combinations were grouped in three separate categories:—(*i*) seedlings of the type of Co. 402, *i.e.*, noble canes requiring

liberal treatment regarding irrigation and manuring, (*ii*) seedlings like Co. 419, *i.e.*, general purpose canes which may profitably be grown either in wet lands or in garden lands, (*iii*) relatively hardy seedlings like Co. 421 which may be grown as semi-irrigated canes either in tropical or subtropical India.

It was felt desirable to divide the seedlings into the above three classes because of the very good preliminary reports about the performance of Co. 419 from certain experiment stations in the Bombay and Madras Presidencies and of Co. 421 from more than one experiment station in North India.

(3) *Selection of Economic types.*—Sixty seedlings were grown in four-row trials and twenty in eight-row trials along with suitable standards. Seven seedlings were finally raised to the status of Co.'s. These are Cos. 432 to 438, and include 2 seedlings of Co. 402 type, 2 of Co. 419 type and 3 of Co. 421 type. Their parentages are given elsewhere in the report.

(4) *Type of seedlings yielded by different crosses.*—Nineteen different crosses were studied for the type of seedlings yielded by each of them. For this purpose a block of one hundred seedlings from each combination was taken, and brix, weight, and number of tillers for each seedling recorded. These data are being analysed with a view to ascertaining the relative merits of the different combinations.

(*b*) RESEARCH

(1) *Flowering habits of certain forms of Saccharum.*—During the season attention was directed to the study of floral characters of 20 varieties. It was found that *Saccharum spontaneum* was the earliest to flower, followed by (*i*) Glagah, (*ii*) the thin and medium varieties and (*iii*) thick canes. The same sequence was noticed regarding closing of the spikelets also. *S. spontaneum* was the first to close, the last being thick canes like Vellai, etc. As regards duration of blooming the time for *Saccharum spontaneum* was 35 to 45 minutes and for medium and thick canes 3 to 4 hours. P. O. J. 2878 was peculiar in that it was the last to open and closed only about 11 a.m. Dehiscence of anthers took place soon after they became pendulous. The slight morning breeze helped the dehiscence of the anthers. Provided there is no heavy breeze pollen clouds are released half to three quarters of an hour after dehiscence. Sessile spikelets open first in thick canes and the pedicelled spikelets in *S. spontaneum* but the opening of both sessile and pedicelled spikelets together was also quite common. Colour of anther does not appear to be the criterion for availability or abundance of pollen in the species of *Saccharum*; as yellowish white anthers in *Saccharum spontaneum* give abundant pollen while the yellowish anthers of *Saccharum officinarum* are usually infertile.

(2) *Vernalization.*—Single budded setts of half a dozen varieties were kept at a temperature of 13° to 15° C., in darkness. The growth of the treated buds after transferring to the field was defective as compared with the controls. The experiment was repeated with only three varieties treated under:

(*i*) continuous darkness, and

(*ii*) continuous electric illumination.

The varieties treated were Co. 402, Co. 290 and P. O. J. 2725. The treated buds along with the controls have been transferred to the field and observations are being made. For electrical illumination a 500 c.p. lamp was used.

(3) *Photoperiodism.*—The varieties P. O. J. 2725, Co. 290 and C. A. V. 87 were given a six hour day for 35 days. The arrows of P. O. J. 2725 and C. A. C. 87 emerged 14 and 12 days respectively earlier than the control. The arrows of Co. 290 also emerged 14 days earlier than the control.

(4) *Root studies.*—Observations were made on the development of roots of two outstanding thick Co. canes, *viz.*, Co. 419 and Co. 421 as compared with three standard varieties, *viz.*, Cos. 213 and 290 and P. O. J. 2878. The root systems are being exposed and studied at intervals of four weeks.

(5) *Germination in thick cane seeds.*—Data were collected on the following experiments:—

(*i*) Number of germinations from different parts of the arrow.

(*ii*) influence of the same male parent on different mothers.

(*iii*) influence of artificial rooting in single and double tile pots (during isolation) on germination.

(*iv*) average germination per arrow in different crosses.

It is proposed to collect similar data for at least three to four seasons.

(6) *Cytological observations.*—Important slides which had been prepared during 1933 and early part of 1934 but which could not be examined owing to pressure of other work were examined by Botany Assistant Mr. K. S. Subba Rao, with a view to the study of secondary pairing. He was able to examine a large number of sections in about a dozen varieties and camera lucida drawings of the same have been prepared. He found that the number of groups formed by bivalents in the metaphase plates ranged from 8 to 10, the latter being by far the most common. This was true even for such forms as *Saccharum spontaneum* (Coimbatore) the haploid number of which is not a multiple of ten. The above might be some indication that the basic number of chromosomes in *Saccharum* might most probably be 10.

(c) Thick type of Co. Canes

Data about parentages and performance of thick cane seedlings are given elsewhere. Among the thick Co. canes extensively distributed to various experimental stations in India are Co. 419 and Co. 421. These two canes have also been distributed, on request, to a few foreign countries as well.

X. MISCELLANEOUS

At the desire of the Sugar Committee of the Imperial Council of Agricultural Research a standard form was drawn up for "Reports from Sugarcane Testing Stations".

At the desire of H. E. H. the Nizam's Government the area under the Nizamsagar Canal was visited and a scheme for varietal tests drawn up.

The Coimbatore Rind Hardness Testing Apparatus was sent to Manila (Phillipines) in exchange for a squeezer evolved there for the sampling of standing sugarcanes.

Mr. Imdad Ali Khan completed his post-graduate training at the Station.

The visitors during the year included Dewan Bahadur Sir T. Vijayaragavachariar, K.B.E., Vice Chairman, Mr. B. C. Burt, C.I.E., M.B.E., I.A.S., Agricultural Expert, Mr. A. M. Livingstone, Marketing Officer of the Imperial Council of Agricultural Research, Dr. F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S., Director, Imperial Institute of Agricultural Research, Mr. S. V. Ramamurthy, I.C.S., Director of Agriculture, Madras, Dr. O. Posthumus of the Sugarcane Experiment Station, Pasoeroean, Java, and Mr. Nizammuddin Hyder, Director of Agriculture, Hyderabad (Deccan).

XI. PROGRAMME OF WORK FOR 1935-36

The breeding work will be carried on with the object of securing improvements on existing types or cheapening cost of cultivation.

Attempts will be made to improve the technique both in the field and laboratory, to study factors in cane germination, and to follow up changes in juice quality particularly towards maturity.

Cytogenetic studies on the genus *Saccharum* will be continued and extended.

XII. PUBLICATIONS

(1) Dutt, N. L. . . Recent advances in Sugarcane breeding in India. *Proc. Assn. Econ. Biol. Coimbatore*—Vol. II, pp. 60-66—1934.

(2) Gopala Iyer, K. V., and Venkatraman, T. S., Rao Bahadur.	Suggested method of juice analyses for sugarcane plantations devoid of Laboratory facilities, Part II. Accepted for publications in *Agri. and Livestock in India.*
(3) Singh, T. S. N. . .	Chromosome numbers in sugarcane × *Sorghum*. *Ind. Jour. Agri. Sci., Vol. IV, Part VI, Decr. 1934,* pp. 1050.
4) Venkatraman, T. S., Rao Bahadur.	Methods of Selecting Seedlings (as adopted at Coimbatore) Contribution to the Fifth Congress of the International Society of Sugarcane Technologists (Brisbane, Australia, August 1935).

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST

(1934-35)

(B. VISWA NATH, F. I. C.)

I. CHARGE

Mr. B. Viswa Nath, on his appointment as the Imperial Agricultural Chemist, took charge of the Chemical Section from Mr. J. N. Mukerjee on the afternoon of the 22nd August 1934 and of the Bacteriological Section from Mr. N. V. Joshi on the 1st November 1934. From this date the Bacteriological Section ceased to be an independent unit and has become part of the Chemical Section. This report, therefore, includes the work on micro-biology which in previous years used to be described in a separate report of the Imperial Agricultural Bacteriologist.

Mr. J. N. Mukerjee, Assistant Agricultural Chemist, was on long leave from 24th October 1934 till the 13th June 1935. During Mr. Mukerjee's absence, Mr. B. M. Amin was in charge of the analytical work.

Mr. N. V. Joshi was in charge of the work on micro-biology throughout the year.

II. GENERAL

The severe earthquake which rocked Bihar on the 15th of January 1934 caused such damage to the laboratories that they became unsafe and unfit for work. It was necessary to provide laboratory accommodation elsewhere. In spite of the uncertainty of the position and dislocation of the normal activities of the Estate, Messrs. Mukerjee and Joshi fitted up temporary laboratories for the conduct of urgent routine work. The salvaging of materials in the damaged buildings and the fitting up of laboratories in other available buildings necessarily took time and it was not till January 1935 that laboratories were available for properly resuming the interrupted research work.

The stocks of apparatus and materials were checked and a list of damages during and incidental to the earthquake, was prepared. It is distressing to mention that several valuable pieces of apparatus were either broken or so damaged as not to be able to function satisfactorily. It will be necessary to replace them if the equipment and the efficiency of the Section are to be at a high level.

Plans for the construction of the laboratories for the new Institute at Delhi and notes on the construction, internal finishings and fittings, were prepared and submitted.

III. METEOROLOGY, DRAIN-GAUGES AND CONTINUOUS DIFFERENTIAL MANURIAL PLOTS

The equipment for these perennial items of work suffered considerably as the result of the earthquake. In view of the shift of the Institute to Delhi in the near future, it was not considered worthwhile repairing the damage. These have, therefore, been discontinued. The data are being tabulated for scrutiny and interpretation.

IV. POST-GRADUATE TRAINING

Mr. Mohini Nath Phookan, M.Sc., completed his two years' training at the end of October 1934. Messrs. Narendra Kumar Das, M.Sc. and K. Swaminathan, M.Sc. entered into their second year's programme of work.

Mr. M. A. Idnani from Sind,

Mr. Sirajuddin Siddique from Bombay,

Mr. S. C. Roy from Assam,

Mr. K. V. S. Satyanarayana from Andhra, and

Mr. C. Parthasarathi from Madras

were admitted as post-graduate students in November 1934.

A new feature of the post-graduate course is the introduction of regular lessons in technical German translations and occasional lectures and discussions on the research work in progress in the laboratories and on the state of the knowledge in different fields of agricultural science.

Three Dairy Diploma students had a course of lectures and practical training under Mr. N. V. Joshi.

Dr. J. K. Dubey, Assistant Director of Agriculture, Bhopal State, who was under general post-graduate training between November 1934 and April 1935, was given facilities to acquaint himself with the work in progress and methods in use in the Section.

V. RESEARCH AND INVESTIGATION

In view of the decision to shift the Research Institute to Delhi in the near future, the Research and Investigational activities of the Section were confined to the completion of the work already on hand or to bring it to such a stage at which it can be kept in abeyance. A few new items which can be conveniently continued at Delhi were, however, taken up.

1. Soils

Delhi Soils.—The bulk of the work on soils consisted in the examination of the soils round about Delhi, preliminary to the selection of a site for the location of the new Agricultural Institute. Two sites, (1) the Gheora site, (2) the Industrial Area site were under consideration as possible localities. Elaborate and careful surveys of the sites were made and a large number of samples of soils, subsoils and waters were collected and analysed. The waters from the Gheora area are extremely brackish in quality and the wells are shallow and are probably mostly from the seepage water from canal irrigation. Judging from the water level in the well, the subsoil water in the area is dangerously near the surface. It was noted to be 15 to 20 feet from the surface in the month of March, 8 to 10 feet in July and in September it was only 4 to 5 feet from surface. The dissolved solid content of the well waters in the Gheora area varied from 250 to 2,150 parts per hundred thousand parts, the salts being chiefly sodium salts with a preponderence of chloride. Such waters lead to soil deterioration from a sequence of exchange reactions, which ultimately result in the introduction of sodium into the clay complex. Soil management would then become difficult and with intensive irrigation and cultivation the soil is likely to soon become infertile. On the other hand, the well waters of the Industrial Area site are decidedly superior to those of Gheora. The total solid content of the well waters of the Industrial area varied from 48 to 125 parts per 100,000 parts of water and at the end of the rainy season, unlike at Gheora, the subsoil water was found not to have risen appreciably. Even then, the subsoil water was below 20 to 30 feet from the ground surface, while the water column in the well ranged from 20 to 33 feet.

Several samples of soils in both the areas were collected down to a depth of 6 to 8 feet and analysed chemically and physically. In regard to their contents of nitrogen, phosphoric acid and potash there is no appreciable difference in both the sets of soil. In regard to lime reserves, the soils of the Industrial Area are better placed than those of Gheora. The differences, though apparently small, are important enough to merit consideration. The mechanical composition of the surface soils of both the sites does not differ, but in regard to subsoils those of the Industrial Area contain 30-34 per cent. of finer particles (clay + silt) as against 27 to 31 per cent for those of Gheora site. In the Industrial Area site *Kankar* occurs at depths of 6 and 12 feet, in loose nodules and is principally of calcium carbonate. From these considerations, the Industrial Area site was considered as being more suitable than the Gheora site for the location of the Institute, and a recommendation was made accordingly. The recommendation having been accepted, further intensive and extensive studies of these soils have recently been commenced. From the data available so far, the soil appears to be typical of old Jumna alluvium. The available data on the

other soil characteristics are as yet too meagre to comment on the nature of the alluvial soil, that is, whether a soil is developing on the old deposited alluvium or whether it is the accretion of successive layers of fresh alluvium.

Pretreatment of soils for dispersion for Mechanical Analysis.—At the instance of the Imperial Council of Agricultural Research the potassium permanganate method of dispersion was investigated in regard to its applicability to soils other than laterite. The method with a few modifications in the technique gives, in the hands of experienced workers, results closely agreeing with those obtained by the International method. But the process is tedious and presents considerable difficulty in the removal of manganese dioxide formed in the reaction. Apart from this, the method is likely to develop with the majority of Indian soils sufficient alkalinity as to disrupt partially the clay complex and to dissolve iron, alumina and silica.

In recent years, the dispersion of soils for mechanical analysis has received considerable attention in and outside India. The desire to get at the ultimate particle size and to present the results in the form of a continuous curve has been the chief consideration that has prompted soil workers to give to the subject the too much attention that it has had. Several methods have been proposed from time to time and in India the older and simpler pretreatment by boiling has been given up in favour of the one or the other newer pretreatments which are entirely chemical. Either from theoretical or practical considerations there appears to be no justification for this change over. A critical study of the several methods in regard to their applicability to Indian soils was in progress. All the methods of pretreatment are more or less drastic and any one method fails to give an accurate picture of the soils' field behaviour. Several so modify the soil chemically and physically that it entirely differs from the original soil. A critical experimental review of the position will be prepared for publication.

Dew as a factor in the supply of moisture to the Soil and to the plant.—A study on dew as a factor in the moisture economy of the soil, and the contribution made to the growth of *rabi* (winter) crops was commenced in the middle of November both in the laboratory and in the pot-culture house with tobacco seedlings. Tobacco seedlings were planted in pots filled with Pusa soil and were fully exposed to all kinds of weather except rain. No watering was done, Dew was the only source of moisture or water. Under these conditions the tobacco seedlings lived throughout the season, passed through the usual vegetative and reproductive phases. Determinations of moisture in soil at different parts of the day indicated that besides supplying 3 to 4 per cent of moisture in the surface layers, dew deposition takes place even in the lower layers of the soil down to a depth of one foot. It would appear that evaporation.

and absorption phases operate in the soil to an extent that the balance is enough to sustain the normal functions of the plant. At or about the hygroscopic stage, the soil loses appreciable amounts of water during daytime, but during night more moisture than is lost is gained both by direct absorption and condensation in the interior of the soil. This increased with the depth of tillage.

The investigation of acid soil.—The investigations on acidity and lime requirements of soils of Jorhat in Assam reported in previous years were continued. The response to the degree of liming as determined by the potentiometric titration of the soil, varied with the nature of the crop. The effect of lime applications made in the year 1932 persisted during the year under report. Maximum crop yield in pots was obtained in the pots limed to pH 7 and the yields decreased with increasing applications of lime. On the other hand barley plants grew well and yielded the maximum when liming was done at twice the amount required to bring the soil reaction to pH 7.

Photo-nitrification in soil.—The recent claims by the workers of the Allahabad University that sunlight is largely, if not entirely, responsible for bringing about nitrification in the soil were tested. Messrs. Joshi and Biswas carried out a series of experiments with different soils and different nitrogenous materials. They have not been able to find any evidence of the effect of nitrification either in soil or in Remy's solution. On the other hand, they find that direct exposure of soil to strong sunlight inhibited nitrification. The results of the investigation are written up and will be submitted for publication.

Biological activity of soils with reference to manurial treatment.—The estimation of nitrogen fixing and carbon-dioxide evolution capacities of soils collected in different seasons from plots receiving differential manurial treatments were completed during the year under report. The results obtained with samples collected in the years 1932 and 1933 do not show consistent and marked differences due to treatment or season.

Biological Analysis—Punjab Field Experimental Plot—Nitrogen Fixation—Mgm. N. fixed per gram of mannite

Plot No. / Treatment	Month	8 Farmyard Manure	10 N+K+P	12 Green Manure	13 No Manure	16 Green Manure and super
1932	March 32	8·47	8·82	6·86	7·77	8·75
	June 32	8·89	9·38	8·26	8·82	9·52
	Sept. 32	7·84	7·84	9·35	8·68	7·14
	Decr. 32	7·63	8·19	7·98	7·49	7·35
1933	March 33	6·44	8·12	8·19	7·63	7·63
	June 33	8·99	9·56	7·63	9·31	9·10
	Sept. 33	8·19	9·31	10·36	8·68	9·35
	Decr. 33	10·36	9·24	7·56	10·89	8·10

CO_2 evolution with optimum moisture only (carbon added).

Mgm CO_2 per 100 grm. soil.

1932	March 32 .	58·96	62·92	55·66	54·78	68·42
	June 32 .	84·04	72·60	81·62	55·66	69·08
	Sept. 32 .	56·76	58·08	54·56	51·70	59·84
	Decr. 32 .	31·68	62·92	52·36	56·76	80·96
1933	March 33 .	69·52	66·00	73·26	59·40	68·64
	June 33 .	88·66	59·40	51·92	42·02	41·80
	Sept. 33 .	69·08	54·34	55·88	66·00	71·50
	Decr. 33 .	60·06	61·16	66·00	59·40	66·00

2. Fertilisers and Manures

Nitrification of Calcium Cyanamide in Soil.—It was reported in previous years that while Calcium Cyanamide nitrified normally in many soils, there were some soils in which it took very long—even as long as seventy-two weeks—to nitrify, although ammoniacal nitrogen was found to form in about two or three weeks' incubation. This lag period varied with the soil. It was also found that the lag period was not connected with the reaction of the soil and that the refractive soils were not lacking in nitrifying organisms. Water extracts from lag cultures did not inhibit or appreciably retard nitrification when inoculated into Omelianski solution, but the residual soil after extraction was distinctly toxic to nitrifying flora. The work during the year under report was a detailed periodical study of the several water soluble and insoluble products formed on incubating calcium cyanamide with the refractive soils. Five soils from Cawnpore, Gujranwala, Peshawar, Dacca and Pusa were selected for the study and work with three soils, *viz.*, Dacca, Cawnpore and Gujranwala was in progress.

Effect of fertilisers on calcareous soils.—The optimum requirements of calcareous soils, as typified by the Pusa soil containing about 40 per cent of calcium carbonate, in nitrogenous, phosphatic and potassic fertilisers, were under investigation :—

(*a*) *Nitrogen.*—Ammonium sulphate on basal dressings of potassium sulphate *plus* superphosphate gave the largest yield of wheat in pot cultures when applied at 30 mg. nitrogen per kilo of soil. On the other hand, in field plots, increasing applications from 40-100 lbs. of nitrogen to the acre resulted in increasing response of

wheat, but the increment due to nitrogen was, however, not proportional. In regard to the composition of wheat grain, the nitrogen content steadily increased with increasing applications of this constituent to the field while the reverse was the case for the phosphate content of the grain. The reduction in the P_2O_5 content was, however, not proportional to the increase in nitrogen. The potash content of the grain was not appreciably affected by the increased absorption of nitrogen.

(*b*) *Phosphate.*—In pot cultures the maximum response of oats to super was with 30 mg. P_2O_5 per kilo of soil. Above this level the yield was almost constant. In field plots *ragi* (*Eleusine coracana*) gave somewhat similar results, the maximum yield being at the level of 70 lbs P_2O_5 per acre. The ash content of the *ragi* grain was not appreciably influenced at any level of fertiliser application in the range 50-100 lbs. P_2O_5 per acre, but its composition varied. Increasing doses of phosphate applied to the field were reflected by a definite, though not proportional, increase in the P_2O_5 content of the grain. There was a tendency on the part of nitrogen to decrease as the P_2O_5 content of the grain was increased but potash was not visibly affected.

(*c*) *Potash.*—In view of the general lack of response observed at Pusa and in several parts of India to potassic manures, pot cultures and field experiments were carried out with applications of potash in the form of sulphate, chloride and carbonate of potash. The response varied with the crop and season and the specific depressing effect of sulphate ion on crop yield was not consistent and definite. The results are being worked up for publication.

Availability of superphosphate in relation to depth of placement.—Further pot-culture experiments carried out during the year with *ragi* as the test crop, confirm the findings reported in the previous year. It has been found that super does not move beyond four inches from the region of its placement. In experiments with super placed at 3, 6, 9 and 12 inches depth, using *ragi* as the test crop, the best result was obtained with placements at 6 inches depth.

Relative availability of artificial and natural phosphates.—In the report for 1933-34 the tests on the availablity of different natural and artificial phosphates applied to Pusa soil were reported. During the year under report the residual effects were measured. Several of the phosphates which showed low response in the previous year for direct application showed high residual effects.

Relationship between citric acid solubility of a phosphatic fertiliser and crop response.—Experiments were carried out to see if any correlation existed between the value for phosphate soluble in two per cent citric acid as determined in the laboratory and the crop response on calcareous Pusa soils as measured by yields from

pot-cultures. The results of experiments with some of the phosphates show no such relationship as will be seen from the table below of the results of pot experiments.

Phosphate	Solubility in 2% citric acid %	% Increase over control		% Growth variation in *ragi* seedlings over control
		Mustard (direct)	*Ragi* (residual)	
Iron phosphate . .	11·20	57·0	58·6	—27·5
Apatite . . .	12·08	22·3	16·6	25·5
Trichy phosphate . .	23·24	32·2	1·3	—29·4
Dicalcium phosphate .	54·68	61·6	27·0	40·2
Superphosphate . .	75·84	127·3	51·2	86·3
Mag. Ammon phosphate	81·47	56·2	7·0	—13·7
Aluminium phosphate .	94·71	19·0	76·0	40·2
Bonemeal . . .	99·49	36·8	—20·9	88·2
Tri-calcium phosphate .	100·00	62·8	69·4	104·0
Potassium phosphate .	100·00	38·8	62·5	150·0
Ammonium phosphate .	100·00	105·0	36·6	200·0
Sodium phosphate .	100·00	40·5	76·6	316·7

Solubilisation of Khudada phosphate.—Two composts of this insoluble phosphate were prepared and tested on the field scale. One compost (sand-sulphur compost) was made up of 'khudada' phosphate 100 lbs., sand 100 lbs., sulphur 25 lbs., charcoal 16 lbs., water 25 lbs.; the other (berseem compost) was made up of khudada phosphate 100 lbs., green berseem 100 lbs., sulphur 25 lbs. The matured composts were tested on the field scale along with the raw phosphate in a finely ground form. Khudada phosphate by itself contributed to an increase of 36 per cent of mustard crop while the sand and berseem composts gave 50 and 45 per cent respectively over control. The increased yield on account of compost is not likely to cover the cost of composting.

Experiments on green manuring.—In previous years it has been shown from laboratory experiments that the yield of wheat after applying sann-hemp tops alone is equal to that when the whole of the sann-hemp plant is buried in the soil. This gives the cultivator the advantage of fibre from the sann-hemp. The experiments were translated to the field scale with confirmatory results. The results of large scale experiments have shown that while the yields of wheat for sann-hemp whole plants versus tops alone were the same, the yield of fibre from the stems remaining after using tops as manure was 500 to 600 lbs. per acre. The full set of results and the economics of the problem will be fully discussed in a report which will soon be ready for publication.

Sugarcane manuring.—These experiments were continued according to the following scheme with the variety Co. 213.

(1) 100 lbs. nitrogen as mustard cake + 20 lbs. K_2O + 45 lbs. P_2O_5.

(2) 100 lbs. nitrogen as mustard cake + 50 lbs. K_2O.

(3) 100 lbs. nitrogen as mustard cake + 100 lbs. P_2O_5.

(4) 100 lbs. nitrogen as mustard cake +50 lbs. K_2O+ 100 lbs. P_2O_5.

(5) 100 lbs. nitrogen as molasses and Ammonium sulphate +50 lbs. K_2O.

(6) 100 lbs. nitrogen as molasses and Ammonium sulphate + 50 lbs. K_2O+100 lbs. P_2O_5.

The molasses used in the experiment contained 5·27 per cent K_2O, 0·50 per cent nitrogen and 0·23 per cent P_2O_5. In the unmanured plots growth stopped by December, but the crop in the manured plots continued to grow till February. The final harvest and analysis results showed that the application of manures was justified economically. For 0·25 acre plots used in the experiment the yield of sucrose for complete manuring was 187 lbs. as against 104·7 lbs. for the plot receiving no manure. The combination of molasses, ammonium sulphate and super, omitting potash, gave as good a result as with mustard cake, potassium sulphate and super. The results are being worked for publication.

Preliminary investigation on certain types of barley seedlings susceptible to white-ant attack.—At the instance of the Imperial Economic Botanist a preliminary investigation was carried out on certain types of barley seedlings which were attacked by white-ants in different degrees of severity. Three types of plants, *viz.*, type 2, type 21 and type 22 were selected. The damage occurred in the early seedling stage at the hypocotyl region and type 21 seedlings suffered most extensively. The original grains as well as the seedlings were germinated in trays and the sugar contents at the early germination stage and after the full development of the plumule were determined. The ash, silica and potash contents were also determined. Type 21 barley seedlings contained the largest amount of sugar, but the difference between this and the other types was not enough to explain the extent of damage. There was sufficient sugar in all the tender seedlings to attract white-ants. Further comparative analyses of the hypocotyl portions of attacked and unattacked seedlings revealed considerable differences in their ash and silica contents. While the unattacked ones contained only about sixty per cent silica on ash, the attacked ones contained only about forty-one per cent silica. This relatively low silica content and the consequent softness might have been the cause of the more extensive damage in type 21 seedlings.

3. Micro-biological

Slime producing organism in sugarcane juice.—It was observed that sugarcane juice kept for some time became slimy. Addition to the juice of water passed through Katadyn pellets or of water

in which Katadyn electroliser was allowed to pass current for one-half hour did not prevent the development of the organism. The organism was isolated and studied. It is short and rod shaped and forms raised watery colonies on ammonium nitrate agar. Although slime is produced, the organisms are not capsulated. Glucose, lactose, saccharose, mannite, dulcite, milk, glycerol, salicin, arabinose, maltose, levulose and raffinose are fermented without production of gas. The organism liquifies gelatine, but it does not produce indol nor does it reduce nitrate.

4. Bacteriophage of root nodule organisms

Sann-hemp (*Crotalaria juncea*), cowpea (*Vigna catjang*), Mung (*Phaseolus radiatus*), Sweet pea (*Lathyrus adoratus*), Kerao (*Pisum arvense*) were under investigation to ascertain (1) whether bacteriophage occurs in all legumes and legume nodules, (2) if it occurs, whether it is the same or different in different types of nodules, (3) if different, whether they form the basis for the classification of nodule bacteria and (4) the relationship of the bacteriophage to the formation or otherwise of nodules.

Test with young plants did not indicate appearance of the bacteriophage in any of the types of plants experimented with. Periodical examinations as the growth of the plants advanced were, therefore, made with the following results:

	2 weeks			4 weeks			6 weeks			8 weeks		
Sann-hemp	—	—	—	—	—	—	—	—	—	—	—	—
Cowpea	—	—	—	—	—	—	—	—	—	—	—	—
Mung	—	—	—	—	—	—	—	—	—	—	—	—
Sweet pea	—	—	—	—	—	—	—	+	+	+	+	+
Kerao	not determined									+	+	+

— — — = *Nil.*
— + + = Bacteriophage found after 2 or 3 filtrations.
+ + + = Bacteriophage found in the first filtrate.

These results, so far as they go, are at variance with those of Laird (1932) who observed that bacteriophage may be isolated readily from young nodules, with difficulty or not at all, from old ones. This will be further investigated.

The specificity of the bacteriophages in the production of lysis on solid medium of cultures by different species of organisms, individually and separately, was tested. Berseem (*Trifolium alexandrium*), sweet pea and Kerao were the plants used. Berseem bacteriophage and Sweet pea bacteriophage touched cultures of berseem and Sweet pea organisms in direct and cross inoculations; while the bacteriophage from Kerao touched only its own organisms and had no effect on berseem or Sweet pea organisms.

Attemps to study the action of bacteriophage on growth of plants in glass bead cultures under sterile conditions, using soil

extract with 2 per cent marmite and 0·05 per cent were so far not successful.

Dissociation of Azotobacter in liquid medium.—The object of this investigation is to ascertain whether different forms of Azotobacter exist in soils, and if so, whether they fix nitrogen in an equal or varying degree as compared to the large globule or oval forms of Azotobacter in Ashby's mannite solution. By several transfers of a laboratory culture of Azotobacter in mannite-marmite broth at pH 7·8—five dissociative forms of the organism could be obtained on the fourth to sixth plate. The nitrogen fixing capacity of the different forms in Ashby's mannite solution was determined in quadruplicate. Description of the dissociative forms and the average nitrogen fixation values are given below :—

Organism.	Description.	Mgm. nitrogen fixed. Average of 4 determinations after deducting value for control.
S. AZ	Large globules and ovals	3·40
D. F *i*	Small Cocci	0·22
D. F *ii*	Short rods with granules	0·12
D. F. *iii*	Coccal rods	—
D. F. *iv*	Cocci (medium)	0·05
D. F. *v*	Cocci (smaller)	0·05

5. Foods and Nutrition

Silage experiments.—In continuation of the previous experiment, dub grass mixed with molasses to the extent of ten per cent was found to make a good silage.

Feeding experiments with bullocks and milch cows.—Feeding experiments were commenced with Sahiwal (Montgomery) bullocks and cows to ascertain the digestibility values of feeds and fodders used, and the suitability and adequacy or otherwise of the ration fed to milch cows. With a ration of rape cake as the concentrate and oat straw as roughage, the percentage digestibility values were : dry matter 59·5 ; protein 51·9 ; fat 57·3 ; fibre 75·7 ; minerals 43·7. With rape-cake and maize silage the digestibilities were : dry matter 59·0 ; protein 58·4 ; fat 80·1 ; fibre 65·0 ; minerals 44·6. Work with other feeds and animals and on the protein requirements of work and milk animals was in progress at the end of the year under report. The data are not yet ready for discussion.

6. Industrial Problems Related to Agriculture

This part of the report deals with work calculated to evolve simple methods and processes suitable for the industrial and commercial utilisation of agricultural produce and waste. A beginning was made during the year under report and will be continued as opportunities are available.

Butter experiments.—Comparative experiments were conducted to test the flavour produced by organisms isolated at Pusa and with imported cultures. Among the isolations so far made, culture No. 6A produces butter of quality comparable with that produced with cultures Nos. 27 and 29 of Hammer. The isolation of flavour producing organisms from Aligarh butter was in progress.

Activated carbon from paddy husk.—Paddy husk and chaff and similar husks from other cereals are waste products in agriculture and if these could be turned to useful account it will be to the advantage of the cultivator. The possibilities of making activated carbon from paddy husk was under investigation with promising results. Activated carbon is useful in the manufacture of *gur*, white sugar and sugarcandy by the Open-Pan system and in refining oils. At present active carbons are imported from abroad at Rs. 1,000—Rs. 1,500 per ton. A simple process has been evolved for the production of active carbon which possesses properties similar to the imported carbon. ' The process is very cheap and simple and does not require elaborate equipment. The whole process has been so simplified that if necessary, the active carbon can be manufactured with the equipment available in a village or town and without the use of mineral acids and alkali hydroxides and by a person of average intelligence and at a tenth or even lower than the cost of the imported product.

The absorption and physico-chemical properties of the activated carbon produced were under study with a view to understand its behaviour in the clarification of sugarcane juice in the Open-Pan system of manufacturing *gur* or white sugar. The new product possesses the property of clarifying surgarcane juice to water white colour and of absorbing other suspended and dissolved impurities. It absorbs organic acids. In a typical experiment with acetic acid, the concentration of acid in solution at the equilibrium stage gave on plotting a parabolic curve. The carbon absorbs anions from inorganic salts followed by an increase in the pH of the solution. Potentiometric titrations do not show a sharp break anywhere in the region of pH 7 indicating that the carbon is capable of acting as a buffer. This property is very useful in the boiling of sugarcane juice.

The use of active carbon in the clarification of sugarcane juice for gur *and sugar manufacture.*—Active carbon prepared as above from paddy husk was successfully employed in clarifying sugarcane juice for the manufacture of *gur* and sugar by the Open-Pan method. A simple technique worked out for the treatment of juice and *gur* and better quality products were obtained from the local market. Besides clarifying and decolorising juice to water white colour, treatment with active carbon raises the purity of juice by three or four units. In experiments with a variety of cane Co. 299, the purity rose from 82·36 to 86·01. Treatment with active carbon

has also the property of checking inversion in the boiling of the clarified juice. For instance, gur made from Co. 281 cane juice without clarification with carbon contained 80·2 per cent sucrose and 4·3 per cent glucose, while the gur from carbon treated juice contained 86·2 per cent sucrose and 2·36 per cent glucose. White sugar comparable in colour and quality, to good factory made sugar can be obtained by the Open-Pan method by treatment with lime for clarification and for preventing inversion. The lime is then removed by phosphoric acid. The juice is then decolorised with active carbon and boiled. Gur prepared by the active carbon process possesses better keeping qualities than the best quality ordinary *gur*.

7. Miscellaneous and general analytical work.

Investigations on the running of *gur* on storage, the composition and malting values of different types of barleys, on preserving indigo pastes and their leuco compounds were in progress. The results have not yet reached the stage for discussion.

General consultative and analytical work.—This is a very useful and important branch of the Section and worked at a high pressure during the year under report. In addition to answering several consultative references of a highly scientific and practical nature received from official and non-official sources, the following samples which were submitted to the Section, were analysed and reported upon :—

Soils	25
Manures and fertilisers	57
Oil seeds	12
Sugarcane and beet	387
Food stuffs and fodders	4
Ganja	3
Tobacco	7
Water	5

Several of the samples were from the Heads of Sections of the Institute in connection with their researches and from the North-West Frontier Province, Baluchistan and Coorg. There were many samples from non-official bodies.

Among samples examined, mention may be made of the following on account of their scientific or economic interest.

The composition of samples of filter press mud from Indian sugar factories was as below :—

	per cent.
Water	60—70
Organic nitrogen	1·03—1·09
Phosphoric anhydride	3·8
Potash (K_2O)	0·4 —1·03

The Director of Agriculture, North-West Frontier Province, sent samples of dried blood in which varying proportions of lime were mixed with the blood before drying. Lower nitrogen values were obtained for samples with 3 per cent lime, due evidently to loss of nitrogen as ammonia. The use of powdered charcoal instead of lime was suggested.

Samples of tobacco-tomato and tomato-tobacco grafts made by the Imperial Economic Botanist contained the following amounts of nicotine :—

Tobacco stock	9·3 per cent nicotine
Tomato scion	1·27 ,,
Tomato stock	*Nil.*
Tobacco scion	0·35 ,,
Ordinary non-grafte l tobacco	3·36 ,,

Nicotine appears to migrate from tobacco stock into the tomato scion, but not from tobacco scion to tomato stock. For the bio-chemist these results are interesting from the point of view of plant metabolism and will be pursued. Samples of wild tobacco and *N. tabacum* leaves contained 0·07 and 0·71 per cent of nicotine respectively.

Samples of sugar beet were sent from Peshawar carefully packed in a deal wood case in the month of May. The external appearance and the composition of the juice indicated deterioration. The roots lost their turgidity and yielded juice with a dark colour. Treatment with activated paddy husk charcoal prepared in the laboratory completely decolorised and yielded a bright colourless juice. This is interesting as being indicative of the possibilities of developing beet *gur* and beet-sugar as small scale agricultural industries.

Samples of Seville oranges from Peshawar were analysed with the following results :—

Average weight of fruit	6·77 oz.
Juice on the weight of fruit	39·68 per cent.
Oil bearing rind on the weight of fruit	41·69 ,,
* * * * * * *	
Acid as citric acid—	
On weight of fruit	1·32 per cent.
,, juice	3·45 ,,
Oil finest quality—	
On weight of fruit	0·19 ,,
,, rind	0·46 ,,
Oil heavy quality—	
On weight of fruit	0·10
,, rind	0·25

Ashes from adhatoda (*adhatoda vasica*) plant sent by the Director, North-West Frontier Province, appear to be a good source of potash as will be seen from the results of analyses given below :—

	per cent.
Lime (CaO)	28·0
Magnesia (MgO)	10·6
Potash (K_2O)	12·8
Phosphoric anhydride	1·8

An interesting sample was that of a sugarcane crop which continued to stand in the field for the second year. It is not usual in India to keep a sugarcane crop for two years, and so far, no periodical analyses of such a crop have been recorded. The date on monthly analyses of samples sent in by the Imperial Agriculturist are given in full.

Composition of the juice of sugarcane Co. 210 during its second year of growth.

(Crop planted early in 1933.)

Laboratory No.	Date of analysis.	Average weight of a cane. lb.	Per cent. Juice expressed.	Brix (Corrected).	In juice.		
					Sucrose. %	Glucose %	Purity. %
1934							
107	8-2-34	1·63	66·39	17·94	15·45	0·24	86·11
352	28-5-34	1·65	65·45	20·41	17·40	0·78	85·27
372	12-6-34	1·86	65·77	19·60	16·84	0·68	85·90
378	27-6-34	1·48	65·30	18·57	15·82	0·62	85·19
375	17-7-34	1·79	69·23	18·44	15·99	0·56	86·75
417	14-8-34	1·66	78·93	18·28	15·74	0·49	86·11
423	28-8-34	1·50	64·20	18·64	16·11	0·39	86·42
437	11-9-34	1·50	..	16·97	14·65	0·46	86·37
464	25-9-34	1·80	66·00	17·28	14·90	0·38	86·26
455	11-10-34	1·37	62·72	17·08	14·65	0·41	85·77
486	26-10-34	1·53	60·66	18·80	16·26	0·52	86·51
506	14-11-34	1·53	60·87	16·97	15·12	0·46	89·10
1935							
1	5-1-35	1·52	65·94	17·20	15·02	0·18	87·33

The history of the samples was not known till the rounds of analyses were over. Otherwise the top-bottom ratios would have been determined and these would have thrown light on the second year's life history of the crop. The condition of the crop throughout the period was abnormally good . All through, the average weight of a single cane was maintained. The purity of juice was maintained high. It had increased from November 1934 to the end of January

1935. From the end of June to the end of October, sucrose in juice decreased somewhat but it rose again. The weather conditions were unusually favourable. There were rainfalls in January 1·96 in., in February 0·57 in., March 0·42 in., June 7·24 in., July 15·27 in., August 15·27 in., September 4·50 in., October 2·76 in., and in November 0·43 inch. The maximum temperature in shade was never more than 108° F., being 107° F. for five days and 108° F. for three days. So there was nothing like drought and drying up of soil, for the cane to dry up quickly and deteriorate.

For the Imperial Mycologist several comparative analyses of normal and borer attacked Co. 213 variety of canes and samples from mosaic experimental plots were analysed. For the Imperial Entomologist samples of Co. 214 and Co. 331 canes, normal and canes damaged by stem, shoot and root borers were analysed. Judging from the composition of the juice it would appear that shoot and stem borers are decidedly more detrimental than the root borer. Juice from root bored cane analysed distinctly better than the normal. In regard to the other two kinds of stem borers, juice from affected canes was poorer in Brix by 2 to 4 per cent, in sucrose by 2 to 5 per cent and in purity by 3 to 12 per cent. From an examination of the split canes, it would appear that the large deterioration in the quality of the juice was due more to the activity of yeasts, and alcoholic fermentation which was distinctly in evidence.

The use of carbon tetrachloride as a solvent in determining the specific rotation of ganja resin was found to give a hazy solution which does not give a sharp demarcation of light and shade in the polariscope. Anhydrous petroleum ether was found to give a clearer extract and consequently more accurate polariscope reading. Extraction with carbon tetrachloride gave a higher amount of soluble matter than petroleum ether, but the specific rotation was found to be lower with the former solvent in two cases out of three.

Sample No.	87/1935		88/1935		89/1935	
	In CCl_4	In petrol ether.	In CCl_4	In petrol ether.	In CCl_4	In petrol ether.
Sp. Rotation .	—141·80	—143·28	—172·02	—203·80	—157·43	—148·17
Resin per cent.	13·60	11·76	15·05	13·56	14·80	13·44

VI. PROGRAMME OF WORK FOR 1935-36

1. The move of the laboratories to Delhi.
2. The completion of the programmes on hand at Pusa.
3. Soil survey and study of the cultivable area of the new Institute at Delhi.
4. Post-graduate training.

VII. CONTRIBUTIONS AND PAPERS FOR PUBLICATION

The following articles were contributed by Mr. B. Viswa Nath:—

1. Presidential address on soil work in India, for the Indian Society of Soil Science.
2. Draft of All India Fertiliser Act for the Imperial Council of Agricultural Research.
3. Notes on All-India soil survey, methods of soil analyses and present position of statistical interpretation of field experiments, for the Board of Agriculture.
4. Review on Agricultural Chemistry in India in 1931-32 and 1932-33, for the Imperial Council of Agricultural Research.
5. Review on Thirty-years' Manurial experiments in India, for the Imperial Council of Agricultural Research.
6. Discussion on the "Methods for testing the degree of ripeness of Sugarcane," for the Congress of International Society of Sugarcane Technologists, Brisbane.

Publications.—The following papers were submitted for publication:—

1. The manurial value of different phosphates in calcareous soil, by S. Das.
2. Studies on the dissociation of *Bacillus cereus*, by N. V. Joshi and S. C. Dutt.
3. An aroma producing lactic acid organism isolated from Indian dairy products, by N. V. Joshi and C. S. Ram Ayyar.
4. Studies in the chemistry of sugarcane:—The Top-Bottom Ratio method of determining the degree of ripeness, by B. Viswa Nath and S. Kasi Nath.
5. Report on investigations on a new and simple process for the manufacture of active charcoal from paddy husk and on the manufacture of "Cream Jaggery" using active carbon, by B. Viswa Nath.

REPORT OF THE IMPERIAL MYCOLOGIST

(L. D. GALLOWAY, M.A.)

(1) MYCOLOGICAL SECTION, PUSA

I. ADMINISTRATION AND STAFF

Dr. M. Mitra was in charge of the Section until December 17th, 1934, when Mr. L. D. Galloway took over the post of Imperial Mycologist.

Mr. H. H. Prasad, previously Assistant in the Bacteriological Section, was transferred to this Section from November 1st, 1934.

II. TRAINING

Mr. S. C. Chowdhury, B.Sc. (Ag.), joined the Section for post-graduate training from January 2nd, 1935.

Mr. R. S. Mathur, M.Sc., a post-graduate student of Lucknow University, worked in the Section from 9th October to 11th November 1934, and Dr. J. K. Dubey, Assistant Director of Agriculture, Bhopal, during portions of January, February and March 1935.

From March 1st to 8th, 1935, three post-graduate dairy students, W. D. E. Perera, N. K. Jadhav, and C. Ekambaram, were under instruction in certain aspects of mycology.

III. DISEASES OF CROP PLANTS

(i) WHEAT

Loose Smut.— Solar heat methods have recently been recommended for the control of loose smut (Luthra and Sattar, *Ind. J. Agric. Sci.* 1934 *4*, 177-199). Experiments carried out during the past year show that these methods can be applied with good results in Bihar, where the sun temperature rises to 130° F. on bright summer days.

Wheat seed of Punjab 8A, with a heavy natural infection, was treated on a suitable day in summer by the two following methods:— (1) seed soaked 8 A.M. to noon, then drained and exposed to sun's rays from noon to 5 P.M. (2) Water contained in a blackened metal drum was exposed from 8. A.M. to noon ; seed was placed in the water, and exposure to the sun's rays continued from noon to 5 P.M. The treated seed was dried and stored until November. On another day a second lot of seed was given the above treatments.

At the time of maturity, the percentage of smutted heads in the replicated plots of untreated seed ranged from 1·54 to 2·03 per cent. Not a single smutted ear was found in any of the plots of treated seed.

Solar treatment was also given to 258 maunds of heavily infected seed at Karnal; no untreated control was possible, but there is strong evidence that the incidence of smut was greatly reduced by the treatment.

Bunt.—Previous observations have indicated that bunt does not develop under Pusa conditions. This has been confirmed during the present year. Grain of Pusa 4 and P. 165 was given a heavy artificial infection with bunt spores, germinated in sand in a cool incubator, and the seedlings were transferred to a plot in Pusa. At the time of harvest there were 1007 ears of P. 4 and 1075 of P. 165, but none showed any sign of bunt. Infected seed of P. 4 was also sown in pots in January 1934, that is, when the temperature was most favourable for germination of bunt spores. The plants raised from this seed also showed no trace of bunt.

An experiment to test the efficacy of various fungicides in controlling bunt was again carried out at Karnal, naturally infected seed of Pusa 114 being used. Six replications were sown, of seed given the following treatment:—(1) control (2) hot water (3) solar heat (4) wet treatment with Uspulun, and dry treatments with (5) Ceresan (6) Granosan (7) copper carbonate, and (8) charcoal and formaldehyde.

The hot water treatment was very successful and has the added advantage of controlling loose smut; solar heat was less successful. Uspulun presents no advantages over the mercury dusts, and in any case, is now withdrawn from the market.

For fifty bunted ears collected at random, the length of ear and the number of spikelets were noted, and compared with fifty normal ears. The infected plants showed a clear reduction in both these characters. This year the presence of completely bunted ears was observed for the first time.

There is evidence that bunt infection is soil borne as well as seed borne. In May 1933 certain plots at Karnal showed 10-15 per cent bunt infection. Eighteen months later seed which had received treatment with a fungicide was sown in these and other plots, and only developed bunt in these plots where bunt had previously occurred. This point is being studied further, but it seems clear that a one year rotation is not sufficient.

Rust.—All three rusts were observed a trifle earlier than usual, the dates for first recorded appearance at Pusa being

December 9th for orange rust, January 7th for yellow rust and January 31st for black rust.

The chief varieties affected in the Botanical Area were Pusa 12 and P. 101, which showed fairly severe attack by orange and black rusts, and in the case of P. 101 yellow rust also.

As in previous years, an estimate was made of the percentage of leaf area covered by orange and yellow rusts ; in the table below similar figures for *Helminthosporium* (*H. sativum* P. K. and B. and *H. tritici repentis* Died.) are included for comparison.

Variety	Orange	Yellow	*Helminthosporium*
P. 4	Trace	*Nil*	24·0
P. 12	14·9	Trace	3·2
P. 52	2·3	1·1	17·5
P. 80-5	2·7	*Nil*	22·6
P. 101	8·8	11·3	15·9
P. 111	Trace	*Nil*	18·4
Local . .	2·1	Trace	6·5

Black rust was most severe on P. 101, moderate on P. 12, and slight or absent on the remaining varieties.

At the Botanical Sub-Station, Karnal, rust was almost absent this year. P. 52 was not sown on a field scale, but as usual showed fairly heavy attack by yellow rust.

Aeroscope slides exposed at regular intervals from October 15th, 1934, to March 15th 1935, and also fresh specimens of wheat and barley rusts, were supplied to Dr. K. C. Mehta, Agra, in connection with his rust research work.

Black Point.—A large number of wheat grains collected at Pusa showed the burnt and brownish appearance known as " black point ". Shrivelling of the grain and discoloration of the glumes sometimes accompanied the disease. On isolating the fungi responsible, seventy per cent of the seed was found to contain *Helminthosporium sativum*, whilst others showed *H. tritici-repentis*, *Alternaria* sp., and *Fusarium* sp. The mycelium occurred within the seed-coat, and surface sterilisation did not destroy it. This is the first record of " black point " at Pusa.

Foot-Rot.—A foot-and root-rot of wheat seedlings was found to be associated with the presence of *Fusarium* sp. and *Rhizoctonia* sp., the former being more common. Specimens received from Sabour also showed attack by *Fusarium*.

Mildew.—*Erysiphe graminis* Lev. was fairly common this season at the Botanical Sub-Station, Karnal.

(*ii*) Oats

Covered Smut.—An examination was made of samples of smutted oats—received by courtesy of the Departments of Agriculture concerned—from 24 areas in Bihar, U. P., Punjab, Sind, and North-West Frontier Province. The results confirmed the statement made in last year's report that the predominant smut in Northern India is covered smut. *Ustilago kolleri* Wille, and not loose smut, *Ustilago avenae* (Pers.) Jensen.

The dry spray method of applying formalin to smutted oat seed was again given a trial this year. Seed for nearly 100 acres was treated at Karnal in October, two to three weeks before sowing. The resulting crop was practically free from smut, infection being below 0·01 per cent as compared with 4 per cent of previous years.

In collaboration with the Botanical Section, a trial was made of the relative resistance to smut of sixty oat types developed at Pusa. Seeds of oat differentials for identifying the physiological forms of covered smut were also obtained by courtesy of Dr. G. M. Reed of Brooklyn and Miss K. Sampson of Aberystwyth. Unfortunately all the oat types remained free from smut, so presumably the smut spores used for infecting the seed failed to germinate. The reason for this is being investigated.

(*iii*) Barley

Helminthosporium disease.—*H. teres* Sacc., first noticed at Pusa in 1930, was altogether absent during the year, possibly owing to treatment of the seed with mercury compounds.

The percentage of leaf area destroyed by *H. sativum* was recorded for 24 types of Pusa barleys, and was found to vary from 1·46 to 10·82 per cent. The range for type 21 grown in nine different areas at Pusa was from 1·68 to 7·83 per cent; the variation appears to be due to time of sowing as well as to locality.

Foot-rot of barley was very bad in plots where barley is grown year after year, and in plots where no seed treatment was given. Experiments carried out with various fungicides show that good control of foot-rot and root-rot caused by *H. sativum* can be obtained by the use of mercury compounds. Such treatments, however, do not prevent secondary infection of the more mature plants by spores from neighbouring fields of wheat and barley or from certain wild grasses which can also act as host. This work has been written up for publication.

(*iv*) Rice

Sclerotial diseases.—Field and pot experiments were again repeated during the year to test the parasitism of *Leptosphaeria salvinii* Catt. (=*Sclerotium oryzae* Catt.). Seedlings of rice type 31 were transplanted early in July to pots and plots, both heavily

infested with the fungus. The plants developed normally and bore well filled panicles. The dried up straw after harvest showed the presence of sclerotia, indicating that development of the fungus had taken place, although, as last year, it had failed to produce any disease symptoms in the plants. The investigation has been written up as a paper, the general conclusion being that this fungus is not a serious parasite under Pusa conditions, nor, so far as present information indicates, under east or south Indian conditions generally.

False Smut.—A quantity of panicles attacked by *Ustilaginoidea virens* (Cke.) Tak. was collected in December 1933 at Maruteru in the Godavery district. This infected seed was grown in pots of normal soil, and healthy seeds were grown in pots of infested soil obtained by mixing the soil thoroughly with infected panicles. In neither case did the resulting plants show any false smut, confirming the records of previous workers that this disease is not seed or soil borne.

(*v*) SORGHUM

Colletotrichum.—Various seed treatments were tried on *Jowar* for the control of *Colletotrichum graminicolum* (Ces.) Wilson. Mercury compounds, formalin, and solar heat treatment were all ineffective. This is in agreement with the results of some previous workers, but not with those of others.

(*vi*) TOBACCO

Black Shank.—In December 1933 a severe root-rot disease of tobacco was observed at Anakapalle in the Vizagapatam district. The symptoms were those of the Black Shank disease of tobacco recorded in America, and examination of the diseased plants revealed the presence of a *Phytophthora*. The Government Mycologist, Madras Presidency, states that this disease had been observed by him in 1930, and regarded as the Black Shank organism, *Phytophthora parasitica* var *nicotianae* Tucker. The present isolations have been compared with authentic Black Shank organisms obtained from workers in Florida and Java respectively, and although somewhat slower in growth, appear to agree well with these cultures.

Experiments carried out in sterile soil show that the Madras *Phytophthora* is a virulent parasite. Under Pusa conditions mortality was low or *nil* in the winter months, but from April to October seedlings transplanted to infected soil show a very high proportion of deaths.

Phytophthora parasitica Dast. isolated from *Ricinus*, and *P. palmivora* Butl. from coconut palm were unable to attack transplanted and mature plants. Under these conditions, *Pythium aphanidermatum* (Edson) Fitz. was also not pathogenic, though this species has previously been shown capable of producing a root-rot in tobacco.

Further studies are in progress on the identity and morphology of the Black Shank fungus, its toxin production, possible control by fungicides, and the relative resistance offered by different tobacco varieties.

Root-rot.—From diseased roots of tobacco two strains of *Fusarium* were isolated. Attempts to establish the pathogenicity of these organisms by mass-infection of soil in which tobacco seedlings were then planted proved unsuccessful.

(*vii*) Potato

The investigation of suitable potato types for Northern India has been taken up by the Botanical Section. As susceptibility to fungal diseases and to the virus diseases bringing about degeneration is an important factor in this connection, the Mycological Section is collaborating in this work. So far only preliminary work has been done, but observation of last year's crop at Pusa has shown that the following diseases are important. (1) Tip or Hopper Burn, (2) *Alternaria* blight, (3) *Rhizoctonia* rot, and possibly also *Fusarium* wilt, (4) Leaf roll, streak, crinkle, and other mosaic diseases.

On the tubers themselves Scab *Spongospora subterranea* (Wallr.) Johnson, and sclerotia of *Rhizoctonia solani* Kühn. have been noticed, while *Fusarium oxysporum* Schelt. has been isolated from rotted tubers. Bacterial rot is common in storage and one of the types commonly found agrees with *Bacterium solanacearum*. Symptoms resembling internal rust or "Spraing" have been observed, but no confirmation could be obtained of the view that this disease is caused by a micro-organism.

(*viii*) Piper betle

Foot-Rot.—It has been found that Phenyl may be used instead of Kerol for controlling foot-rot in *Pan* due to *Sclerotium rolfsii* Sacc., and *Rhizoctonia solani* Kühn. Phenyl is more readily obtainable but requires to be used in a more concentrated solution; this is in agreement with laboratory experiments showing that Kerol has roughly four times the inhibiting power of Phenyl. Pot experiments are being repeated this year to confirm the lowest effective concentrations of these antiseptics, and to try other possible substances.

(*ix*) Cinchona

Seedling disease.—A serious disease of cinchona seedlings was first observed in the Darjeeling district in 1928. The collar is attacked, and the discoloured area gradually extends upwards until it reaches the cotyledons which become limp and bend over. The leaves turn yellow and curl inwards and in some cases they are shed. A species of *Phytophthora* was found to be present in

diseased seedlings, and inoculation experiments have proved its pathogenicity. The morphology of the fungus, its systematic position, and its ability to infect other hosts, have been written up and the paper is in course of publication.

(x) Miscellaneous Fruits and Vegetables

Asparagus.—A stem disease of Asparagus noticed at Pusa has been investigated. Light brown patches are formed on the stem, which eventually becomes dry and brittle, with small dark pycnidia on the discoloured areas. The organism, a species of *Phoma*, has been isolated and its pathogenicity confirmed by inoculation experiments.

Grape vine.—A white rot disease of grape vine has been observed at Pusa. The stem and leaves of affected plants become brown and shrivelled and pycnidia are formed; in advanced cases the berries become brownish grey and slowly dry up. The systematic position of the organism concerned is still under study but it appears to be a new species of *Coniella*. The one-celled conidia are borne all round the inner surface of the pycnidia; they are hyaline when young and dark brown when mature. The perithecial stage also occurs. Inoculation experiments show that infection can take place through wounds.

Fruit trees.—An account of fruit tree diseases collected in Baluchistan has been written up and is being submitted for publication.

It has not been possible to make any tour of fruit growing districts during the year, but over a hundred specimens of fruit diseases have been received for examination and advice.

Tomato.—Wilted tomato plants were received from the Balasore district of Orissa, and the wilt was shown to be due to *Bact. solanacearum*.

Brassica spp. Bacterial rots of cauliflower, cabbage and turnip were observed at Pusa during March, and the study of these will be continued next winter.

IV. MISCELLANEOUS

Helminthosporium.—A fungus found to be the cause of a seedling disease of sugarcane has been found to agree closely with *H. halodes* var. *tritici* Mitra, previously recorded on wheat in India. In addition to this species and *H. sacchari* Butl. a third species of *Helminthosporium* occurs on sugarcane, and its morphology is being studied.

From *Euchlaena mexicana* a species of *Helminthosporium* was isolated which appears to be *H. maydis* Nishikado or a related species.

Colletotrichum.—A large number of *Colletotrichum* strains from various pulses are being examined and compared. There would appear to be several distinct species of this genus occurring on

pulses. A strain isolated from mid-rib of maize has been shown to be pathogenic, and is being compared with known species occurring on grasses.

Rhizoctonia.—Two isolations of sclerotial forms from betel vine show considerable differences from the usual species of *Rhizoctonia*, and are being studied further.

Small plot experiments were made with wheat seedlings to determine whether attack by white ants preceded or followed *Rhizoctonia*. The results require confirmation, but suggest that in cases where signs of both *Rhizoctonia* and insect attack are found, it is the latter which has occurred first.

Phytophthora.—The stimulation of oospore production in certain strains of *Phytophthora* by growing in association with another strain is well known. In order to determine whether this is due to chemical stimulation as opposed to heterothallism, an unheated filtrate (Chamberland filter) from a paired culture of *P. meadii* McRae and *P. colocasiae* Raciborski (strains not producing oospores) that had formed oospores was added to quaker oat agar, and plate cultures of these species were grown separately. *P. meadii* in the presence of the filtrate formed amphigynous oospores at 23°C. At this temperature, *P. colocasiae* formed no oospores, but at the higher temperature of the laboratory a few were formed. The experiments are being continued with filtrates of pure cultures and with heated filtrates.

A species of *Phytophthora* causing fruit rot of *Polyalthea longifolia* has been isolated, and its pathogenicity demonstrated. Cross inoculations with this and *Phytophthora parasitica* from castor gave positive results.

New records.—The following records are, so far as is known, new for India :—

Kawakamia sp., from *Cyperus tegetiformis* at Pusa. The fungus agrees with *K. cyperi* (Miy. et Ideta) Miyabe, but attempts to grow it in culture have failed.

Puccinia Prostii Moug., from *Tulipa* sp. received from the Agricultural Officer in Baluchistan. The spiny teleutospores are very characteristic.

Cystopus candidus (Pers.) de Bary from *Merremia emarginata*.

Soil Fungi.—A number of different soils from Pusa, and two from other sources, have been examined by the plating-out method. From samples taken during the first half of the year, the main points noted are :—

(1) The predominance of *Aspergillus*. Ascosporic strains of *A. nidulans* occur in all samples, and *A. niger*, *A. terreus and A. ustus* are also common.

(2) *Penicillium* and *Mucorales* are less common than in temperate climates—the former probably on grounds of temperature, and the latter on grounds of moisture.

(3) *Cladosporium* and *Fusarium* are very frequent as in most soils.

(4) The usually abundant soil types *Trichoderma* and *Asp. fumigatus* have not so far been encountered, although the former occurs as a saprophytic growth on sugarcane.

Other isolations include *Rhizopus arrhizus*, *Cunninghamiella* sp., *Chaetomium indicum*, *Alternaria* spp., *Helminthosporium sativum*, *Acrothecium lunatum*, *Phoma*, *Melanconium*, *Byssochlamys*, and *Trichosporium*.

Soil temperature.—Soil temperature at depths of six inches and twelve inches have again been recorded throughout the year. This record has now been discontinued.

Fungicides.—Tests have been started to determine the possibilities of some of the newer organic antiseptics for seed treatment, sprays, or soil disinfection. Malachite green shows promise, and is not prohibitively expensive.

The antagonistic action of *Trichoderma* to certain pathogenic soil fungi has also been confirmed.

Seed treatment.—The following seed treatments were carried out for the Botanical Sub-Station at Karnal: in October 1934, 227 maunds of wheat were given hot water treatment, and 75 maunds of oats were sprayed with formalin; in May-June 1935 803 maunds of wheat were given hot water treatment.

Herbarium and Cultures.—During the year 83 herbarium specimens have been added to the collection, 18 of these being received from outside sources. Revision of the herbarium list is now almost complete. Work on identification of half named specimens has been continued.

About 60 specimens and cultures have been sent out in response to requests from other workers.

Identification and advisory work.—Over 200 specimens, half of these being fruit diseases, have been received during the year from the provincial Departments of Agriculture, the Universities, and from other sources. These have been reported on, and where necessary advice has been given regarding control measures.

Dr. K. D. Bagchee, Mycologist to the Forest Research Institute, visited the Section from April 15th to 30th, 1935, and help was afforded him with identifications.

Miscellaneous.—The section on plant diseases for the Review of Agricultural Operations in India 1931-1933 was written by Dr. M. Mitra at the request of the Imperial Council of Agricultural Research.

Two papers were read by Dr. M. Mitra, and one by Dr. B. B. Mundkur, at the Indian Science Congress held at Calcutta in January 1935.

V. PROGRAMME FOR 1935-1936

The necessity for improvised laboratory accommodation since the earthquake of January 1934, though causing a certain amount of discomfort and difficulty to the workers concerned, has not appreciably retarded the progress of the work in hand. The coming year, however, will be marked by preparation for the transfer of the laboratory to Delhi, and some dislocation of research work will be unavoidable.

The programme as contemplated at present includes the following :—

1. Studies on cereal smuts'
2. Foot-rot diseases of cereals
3. Control of foot-rot diseases of *Pan*
4. Virus and other diseases of potato
5. Comparative study of *Colletotrichum* strains from pulses and cereals
6. Black-shank disease of tobacco
7. Study of the fungus-flora of soils
8. Test of fungicides for seed treatment and soil disinfection
9. *Phytophthora* investigations
10. Study of fruit diseases
11. Investigations on various fungal and bacterial diseases of minor importance.

VI. PUBLICATIONS

Kheswalla, K. F.. . . Seedling Blight of Cinchona caused by *Phytophthora palmivora* Butl. in the Darjeeling District. *Ind. J. Agric. Sci.* 1935, *5*: 485-495.

Mitra, M. . . . Stinking Smut (Bunt) of wheat with special reference to *Tilletia indica* Mitra. *Ind. J. Agric. Sci.* 1935, *5*: 51-74.

Mitra, M. and Bose, R. D. . *Helminthosporium* diseases of Pusa barleys and methods for their control. *Ind. J. Agric. Sci.* 1935, *5*: 450-484.

Mundkur, B. B. . . . Parasitism of *Sclerotium oryzae*. Catt. *Ind. J. Agric. Sci.* 1935, *5*: 393-414.

Do. . . . . The Influence of Temperature and Maturity on the Incidence of Sann Hemp and Pigeon Pea Wilt at Pusa. *Ind. J. Agric. Sci.* 1935, *5*: 609-618.

(2) SCHEME FOR RESEARCH ON MOSAIC AND OTHER DISEASES OF SUGARCANE

(*Financed by the Imperial Council of Agricultural Research, 1934-35*)

I. CHARGE

Dr. S. V. Desai remained in-charge until January 31st, 1935, when he left to take up the post of Bacteriologist, Agricultural College, Lyallpur. Pending the appointment of a successor to Dr. Desai, the duties of Sugarcane Mycologist have been taken over by the Imperial Mycologist in addition to his own duties.

II. MOSAIC DISEASE OF SUGARCANE

Distribution

Mosaic has been observed for the first time on the following two varieties:

Co. 371 (Sepaya),

Co. 395 (Pusa, few. clumps only).

Other susceptible varieties have been given in previous annual reports.

A survey was made in July 1934 of six estates in North Bihar to estimate the percentage of mosaic infection in field cane. The results are given in the table below, and the percentages recorded during similar surveys in three previous years are attached for comparison:

Variety	1934			Percentages in		
	Total area examined (acres)	Number of localities included	Percentage mosaic infection	1927	1931	1932
Co. 213 .	20·92	6	0·12	0·03	0·2	0·58
Co. 210 .	1·84	4	0·26	0·5	0·96	0·09
Co. 285 .	1·3	3	0·34	..	..	0·12

Natural spread

The following 24 varieties: Co. 210, 213, 214, 285, 299, 312, 313, 331, 342, 349, 351, 356, 387, 388, 393, 395, 396, 397, Tuc. 393, Tuc. 472, Uba, Saretha, P. O. J. 2878 and Lalgirah, were grown with alternate rows of mosaic-infected Co. 213. All varieties remained free from infection except for Co. 395, in which two clumps out of 120 developed mosaic. During previous seasons this variety has remained free from infection.

Tonnage Experiment

The tonnage experiment at Pusa was carried out on the line laid down in previous seasons. The land was a good sandy loam but unfortunately the earthquake of January 1934 interfered considerably with the progress of the experiments. Fissures appeared in the plot, and owing to breakage of pipes the water supply was cut off for some time. Consequently the usual crude oil emulsion treatment could not be given, and the cane suffered severe attack by white ants.

The plan of the experiment was as follows: The plot, which had received green manure the previous season; was well levelled, and superphosphate and rape cake at the rate of 40 lbs. and 10 maunds per acre respectively were applied before sowing. 36 plots, each 5×56 yards, were laid out in adjacent pairs, sown with mosaic-infected and healthy canes in the order H. M. M. H. etc. Setts of Co. 213 were sown in the last week of February 1934, and germination was good in all plots; there was no spread of the disease to the healthy plots.

Later observations on the extent of insect attack were made by the staff of the Imperial Entomologist, and the mean differences were found not to be statistically significant. Some "Yellowing" of the leaves appeared in August, but on the soil being given cultivation the plants soon recovered.

Analysis of the plots was carried out during the last week of February 1935. On the advice of the Statistician only plots Nos. 13 to 32 were taken for the experiment and the rest rejected. A margin of 3 yards on each side was also rejected so that the size of the plot was reduced to 5×50 yards.

Ten feet of cane from each line, *i.e.* 50 feet from each plot, was taken for analysis, which was carried out by the Imperial Agricultural Chemist.

TABLE I

Samples taken from 11th to 14th February 1935.

Plot		No. of canes		Weight of canes and juice in pounds				Percentage extraction		Brix corrected		In juice Sucrose		Glucose		Purity	
				canes		juice											
F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
13	14	146	121	135	97	89	63	66	65	18·03	18·53	15·54	16·11	0·61	0·48	86·18	86·95
16	15	149	165	113	124	74	77	65·5	62	18·58	18·70	15·84	16·08	0·51	0·44	86·27	86·17
17	18	151	135	152	124	99·5	81	65·3	65·6	17·97	17·49	15·23	14·78	0·58	0·53	84·74	84·48
20	19	141	121	125	121	80·5	81	66·5	64·8	18·41	18·70	15·95	16·17	0·42	0·45	86·49	86·64
21	22	130	133	123	136	88	87·5	66·1	64·3	18·44	17·67	15·97	15·01	0·37	0·50	86·57	84·91
24	23	110	190	123	164	79	103	64·2	62·8	17·94	17·43	15·40	14·63	0·47	0·51	85·84	83·92
25	26	114	117	135	133	90	85	66·6	63·9	17·63	18·27	15·15	15·89	0·47	0·38	85·98	86·95
28	27	141	113	141	136	91	86	64·5	63·2	18·37	17·71	15·95	15·12	0·42	0·52	86·84	85·49
29	30	120	107	136	113	88	71	64·7	62·8	18·61	18·31	15·60	16·13	0·40	0·49	86·68	85·17
32	31	140	92	165	116	106	76	64·2	65·5	18·04	17·80	15·35	15·17	0·47	0·47	85·06	85·24

The yield of stripped cane in maunds was as follows :—

TABLE II

Weight in maunds of stripped cane Co. 213

Plot F	Plot M	Mosaic-free	Mosaic infected
13	14	20·36	13·17
16	15	16·99	11·83
17	18	18·46	16·68
20	19	18·72	13·79
21	22	18·89	21·00
24	23	20·20	22·61
25	26	21·00	20·35
28	27	17·69	18·19
29	30	19·27	19·20
32	31	21·31	17·93
Mean		19·489	17·475

Difference 2·014 maunds or 10 per cent. is significant.

The statistical significance of the differences in yield shown above and of the other differences as shown by the analysis of the randomised samples, was calculated by Student's method and gave the following results :—

TABLE III

Co. 213.	Mean differences (mosaic-free minus mosaic)	Standard deviation	Mean difference / Standard deviation	Odds
Weight of cane . .	2·014	2·89	·7	30:1
Percentage juice to cane	1·4	1·27	1·1	216:1
Calculated juice per plot	7·45	15·8	·47	11:1
Brix	·14	0·47	·3	4:1
Sucrose . . .	·2	·6	·3	4:1
Glucose . . .	·005	·07	·07	..
Purity . . .	·5	·99	·5	11:1

The difference in weight of cane, and juice to cane were statistically significant. The quality of the juice as measured by brix, sucrose, glucose and purity was not affected.

A tonnage experiment on Co. 213 was again carried out by the Plant Pathologist, U. P., at the Cawnpore Research Farm. The decrease in yield of mosaic infected cane was, however, not sufficiently great this year to be statistically significant.

PROPERTIES OF MOSAIC VIRUS

Distribution throughout cane.—Setts from various positions on 100 mosaic canes of Co. 213 were compared for germination and mosaic development.

TABLE IV

Position	%germination	%mosaic shoots
1 (top)	45	45
2	25	33
3	17	24
4	13	30
5 (base)	8	42

The germination of the basal sett is seen to be low, and there is a strong suggestion that the mosaic percentage is lowest in the middle portions, though more experiments are required to make the latter point definite.

Treatment of setts.—Setts from mosaic clumps subjected to various steeping treatments gave the following results:—

TABLE V

Treatment	%germination	%mosaic shoots
Bordeaux mixture (4 : 4 : 50), 2½ hours	50	28
1% "Clensel oil", 1½ hours	31	35
Hot water (55°-60°C), 1 hour	36	22
Water (unheated), 24 hours	34	8
Lime solution (saturated), 2½ hours	0	..
No treatment	40	11

Soaking in water thus appears to have little effect, whereas treatment with heat and certain chemicals increases the disease.

Artificial transmission.—Inoculation experiment during the present season have been marked by the consistently low percentage of successful infections. A comparison with the weather records and dates of inoculation in previous years failed to show any correlation of this poor transmission with humidity or temperature. A more probable cause is an increased resistance of the varieties used—Co. 213, and to a lesser extent Co. 210—both of which have been consistently rogued at Pusa. In support of this suggestion the following figures are of interest; they show the decrease in mosaic percentage in the tonnage plot rows planted with setts from mosaic plants only:

1931	1932	1933	1934
57—71 per cent	52—75 per cent	40—56 per cent	31—45 per cent.

Other varieties of cane, and Co. 213 and 210 from other areas will therefore be tried as test plants. In the meantime, it has been demonstrated that maize can be used as a test plant for sugarcane

mosaic juice, giving consistent 50-80 per cent infection, and providing a longer working season. Results obtained in this way will of course require confirmation on sugarcane.

Inoculation experiments with (1) mosaic leaf juice passed through L_3 Chamberland filter, (2) healthy juice+(1), and (3) unfiltered mosaic juice, produced mosaic symptoms from (3) only, the percentage infections being 10 per cent. for Co. 213 and 50 per cent. for maize.

Mosaic leaf juice heated to 50°, 60°, and 70°C for 10 minutes gave no infection on Co. 213, the unheated juice giving 20 per cent. infection. Further experiments were made, using maize, with heat treatment at lower temperatures; 45°C gave no infection, whilst 40°C gave 60 per cent. mosaic. The thermal death point therefore lies between 40° and 45°C, in which it resembles that of tomato spotted wilt, and of crinkle and mild mosaic of potato.

Inter-varietal transmission—Mosaic leaf juices of five varieties were inoculated into each of ten varieties, and where mosaic was produced, a water-colour record was made of the pattern produced. The result of 10 inoculations on each variety are shown in the table.

TABLE VI

	Co. 213	Red Mauritius	M 16	Co. 313	Saretha.
Co. 213 . .	4 plants	*Nil*	*Nil*	*Nil*	3 plants
Co. 210 . .	*Nil*	*Nil*	*Nil*	*Nil*	*Nil*
Co. 313 . .	2 plants	*Nil*	*Nil*	*Nil*	2 plants
Co. 416 . .	7 plants	3 plants	1 plant	1 plant	2 plants
Co. 419 . .	1 plant	*Nil*	*Nil*	*Nil*	*Nil*
Co. 420 . .	6 plants	*Nil*	*Nil*	1 plant	1 plant
B 3412 . .	8 plants	3 plants	4 plants.	4 plants	4 plants
Lalgira* . .	4 plants	1 plant	*Nil*	3 plants	1 plant
Saretha . .	4 plants	*Nil*	5 plants	6 plants	1 plant
P. O. J. 2878 .	*Nil*	*Nil*	*Nil*	*Nil*	*Nil*

* This variety has not previously been observed to show mosaic.

Nature of virus.—The work recorded in previous years on the association of mosaic virus with an organism having a visible cyclostage has been written up for publication.

Attempts to secure fresh isolations of this organism in 1935 have not so far met with success. It is possible that they were started too late in this season.

III. BACTERIAL AND FUNGAL DISEASES OF SUGARCANE.

STINKING ROT

This disease was first recorded in last year's report, and was shown to be caused by an organism of the *Bacterium pyocyaneum*

type. Further work has shown that two organisms are present, one giving whitish, and the other bluish colonies on nutrient agar. Inoculation experiments demonstrated that the bluish strain was pathogenic, the whitish strain being saprophytic, but that a mixed culture was the most effective in bringing about the disease artificially. Needle inoculation was not very successful. Removal of a plug of tissue and introduction of the culture, followed by replacement of the plug, gave a fair percentage of successful inoculations. Introduction of the culture through borer holes, however, gave uniformly successful results, and it is believed that this is the usual method of natural infection.

A fuller description of this disease has been written up in the form of a paper, which has been submitted for publication.

ASSOCIATION OF MICRO-ORGANISMS WITH BORER ATTACK

Early in 1935 complaints were received of the prevalence of so-called "red-rot" in parts of Bihar. If the apparently healthy canes as received at the mills were split open longitudinally, a varying percentage showed reddening of the inner tissues. The discoloration was usually localised, but sometimes spread throughout the entire length. It was demonstrated by Mr. Noel Deerr that the sugar content of such canes was frequently reduced to one half or one third of that of the healthy canes.

Visits to the affected areas showed that this type of red discoloration had no connection with the true "red-rot" disease caused by *Colletotrichum*. It was observed that affected cane was always attacked by borers, and that the reddened areas were localised at, or spreading from, the holes made by borer; borer holes unaccompanied by internal reddening were rare.

Examination in the laboratory showed that in nearly all cases of discoloration micro-organisms were present, but that these were all common saprophytic mould fungi, yeasts, and bacteria such as one would expect to find on a sugary substratum freely exposed to air infection. Many fungi give a red coloration on sugar media, and it is probable that the reddening of bored cane is largely, though not entirely, due to such fungi. No parasitic fungi were associated with this type of reddening, which is moreover, different in appearance from the discolorations produced by *Colletotrichum falcatum* and *Cephalosporium sacchari*.

It is clear, therefore, that the primary trouble is the prevalence of borer, and that the fungal and bacterial infection is purely secondary. That this type of discoloration has not been brought to notice before is attributable to the facts that apparently healthy cane has not been examined in this way in previous years, and that borer attack has been less widespread.

Local Survey.—A survey was made of the material arriving at nine mills scattered throughout North Bihar, and the data collected

confirmed the above conclusions. Of canes taken at random, the number of discoloured canes ranged from 30 per cent. to 78 per cent, and of these unsound canes the percentage of the reddened portion ranged from 12 per cent. to 31 per cent. The sugar content was reduced to one half or one third in the immediate neighbourhood of the borer holes, but the remainder of the cane showed a slighter loss.

Cause of reduced sugar content.—It was considered that the lower sugar content of bored and reddened canes might well be due to utilisation of sugar by the infecting micro-organisms. In this case one would expect the loss to increase rapidly with time.

Experiments were therefore carried out to determine the effect of storage on the sugar content of bored cane. Healthy and bored canes were stored at a temperature ranging from 47°F to 75°F for 10 days, 100 canes being taken each day for examination.

It was found that although the percentage discoloration of the bored canes increased steadily from 30 per cent to 58·5 per cent there was no notable loss or inversion of sugar by fermentation during this time. Neither sound nor unsound cane showed any appreciable change in weight, extraction, Brix, or sucrose, though there was a slight increase in glucose in the bored canes during storage. Microbiological action is therefore slight, and moderate storage is no more objectionable for bored than for sound cane.

Bacterial and yeast counts of the pressed juice were surprisingly high, and were at first greater for the bored cane. It was found, however, that the greater proportion of these organisms, which were shown to be capable of inversion and fermentation of sucrose, came from the surface tissues and the immediate neighbourhood of the borer holes.

The above experiments indicate that loss of sugar due to micro-organisms is very localised and that the reduced sugar content of bored cane is principally due, not to loss of sugar, but to interference with the metabolism of the plant which prevents the normal production of sugar.

Smut (*Ustilago scitaminea* Syd.)

In addition to varieties recorded in the last report the following were found to show smut infection at Karnal Sugarcane Substation :

Co. 205, 346, 349, 368, 380, 381, and 391. The fungus was isolated from Co. 205, 213, 290, 368, and 391, and was found to grow well on potato-dextrose agar, Richard's agar, and Dox's agar. In artificial cultures chlamydospores are rare, but secondary sporidia are freely formed. So far little morphological difference can be detected among the various strains.

Smut infection of P. O. J. 2878, Co. 416 and Co. 419 was successfully obtained by infecting the buds of setts with smut

spores or sporidia ; in one case infection took place through the cut ends.

RED ROT (*Colletotrichum falcatum* WENT.)

Five strains of this fungus are under study isolated from thick cane at Coimbatore, Deshi thick cane at Patna, thin cane at Sepaya, and from Co. 210 and 213 at Pusa. The fungus grows well on Richard's agar, abut only the Coimbatore and Sepaya strains have produced spores freely.

SEEDLING DISEASES

Helminthosporium.—Seedling disease was again examined at Coimbatore. The principal causal organism, tentatively regarded as *Helminthosporium sacchari* in last year's report, has now been indentified as *Helminthosporium halodes* Drech. Isolations from sugarcane—which is a new host recorded for this fungus—have been successfully inoculated into wheat, barley, maize and jowar.

Seed and soil treatments with an organic mercury fungicide has given successful control ; a 0·25 per cent. solution of Uspulun was used, but the manufacture of this product seems to have been discontinued in favour of the mercurial dusts. Treatment in the seedling pans was found sufficient at Coimbatore, the transplanted seedlings remaining healthy in the field.

Seed brought to Pusa for germination also developed the disease, but it cannot yet be stated with certainty that the disease is seed-borne

A more weakly parasitic strain of Helminthosporium isolated from diseased seedlings has been identified as *H. tetramera* Mackinney.

Pythium spp.—A species of Pythium isolated from diseased seedlings from Coimbatore early in 1935 appears to agree morphologically with *P.graminicolum* Subr, and can infect maize and jowar seedlings. Another strain of *Pythium* from seedlings growing at Pusa belongs to the *Nematosporangium* group, and has so far failed to form oospores in culture. A *Pythium* of the *Sphaerosporangium* group was isolated from stems of Co. 210, and differs in its morphological characters from all recorded species.

Experiments on culture media of pH from 3·5 to 9·5 indicate that the optimum pH for growth is 5·5 for *Colletotrichum* and *Thielaviopsis*.

IV. PROGRAMME FOR 1935-36

The programme for the coming year is subject to modification, but the following are among the lines of research anticipated :

1. Continuation of tonnage experiment, if possible with thick canes.

2. The purification and transmission of sugarcane mosaic virus, and its physical properties.

3. Fungi—

(*a*) Physiological studies of different strains of *Colletotrichum falcatum*.

(*b*) Varietal resistance to Smut.

(*c*) Studies on *Pythium* spp.

(*d*) Survey of cane crop for disease.

V. PUBLICATIONS

Abstracts of the first three papers below, and also a paper by Mr. S. A. Rafay on "Recovery of chlorophyll in certain varieties of mosaic-infected canes," were read at the Indian Science Congress, held at Calcutta in January 1935.

Desai, S. V. . . .	Stinking Rot of Sugarcane, Ind. J *Agric. Sci.* 1935 *5* : 387-392.
Do.	Organisms associated with sugarcane mosaic and their relation to mosaic virus. *Ind. J. Agric. Sci.* 1935, *5* : 367-386.
Rafay, S. A. . . .	Physical Properties of Sugarcane mosaic virus. *Ind. J. Agric. Sci* 1935, *5* : 663-70.
Subramaniam, L. S. . .	Common Diseases of Sugarcane and methods for their control. (Bulletin in course of Publication).

REPORT OF THE IMPERIAL ENTOMOLOGIST

[HEM SINGH PRUTHI, M.Sc., PH. D. (CANTAB.)]

I. ADMINISTRATION

Mr. P. V. Isaac, Officiating Imperial Entomologist, remained in charge of the Entomological Section up to 4th September 1934. Dr. H. S. Pruthi joined as Imperial Entomologist in the forenoon of the 5th September 1934, and remained in charge of the Section for the rest of the year under report.

Mr. P. V. Isaac, Second Entomologist (Dipterist), proceeded on leave on average pay for eight months combined with leave on half average pay for two months with effect from 2nd January 1935, in continuation of the Christmas holidays.

Rai Bahadur C. S. Misra, Assistant Entomologist, was on leave on average pay for four weeks with effect from 25th November 1934. He again went on leave on average pay for three months and twenty-five days with effect from 21st March 1935 preparatory to retirement.

II. TRAINING

Mr. Hira Nand Batra, post-graduate student from the N. W. F. Province, completed his course and left Pusa on 31st October 1934.

Mr. E. J. Vevai, post-graduate student was under training throughout the year. In addition to the work on general economic entomology he was carrying out a special investigation on the morphology and bionomics of the sugarcane root borer *Emmalocera depressella*.

Mr. K. V. Rao was admitted as a post-graduate student on 1st November 1934.

Mr. Ram Mohan Rao, a post-graduate student of the Benares Hindu University worked on Coccidae in the Section for about a week during January 1935.

The Dairy students were given a series of lectures and demonstrations on insects of veterinary importance.

Dr. J. K. Dubey, Agricultural Officer of Bhopal State spent some time in this Section familiarising himself with important insect pests of crops.

III. SPECIAL INVESTIGATIONS

For a fairly long time in the year under report the Imperial Entomologist was the only gazetted officer on duty. He had therefore to spend great deal of time in the training of students and

in attending to all kinds of routine work of the section. Furthermore, as explained hereafter, considerable amount of time had to be devoted to the proper storing, preservation and re-arrangement of the valuable Insect collections and scientific records of the section which had got badly damaged and mixed due to the earthquake of 1934. The collections required immediate attention of the whole staff to save them from further damage by moulds, pests, etc. It will thus be seen that only limited amount of time could be devoted to research work. Special investigations on the following problems were carried out :—

Pests of Sugarcane.—For the last several years Rai Bahadur C. S. Misra, Assistant Entomologist, had been taking observations on the more serious pests of sugarcane but in February 1935 the Imperial Entomologist himself took over this work in view of the impending retirement of the Assistant Entomologist.

At the time of the harvest of 1934-35 crop in February about eleven thousand canes were carefully examined to determine the comparative incidence of various pests. The results are tabulated below :—

Name of field	Variety of cane	Healthy Per cent.	Top-borer Per cent.	Stem-borers Per cent.	Root-borer Per cent.	Termites Per cent.
Gonhri .	Co. 331 .	22·36	55·37	15·40	45·22	1·08
Pangarbi	Co. 214 .	5·75	82·11	60·95	43·11	9·59

As usual numerous canes were infested by more than one pest, the most common combination in the case of Gonhri field being top+root borer and in Pangarbi field top+stem+root borer and top+stem borers.

Thus the top-shoot borer (*Scirpophaga nivella*) proved to be the most serious pest. The root borer (*Emmalocera depressella*) also attacked a fairly large percentage of canes, but the economic loss due to its infestation was proportionately very small. Among the stem borers *Argyria sticticraspis* predominated, *D. venosata* and *Chilo zonellus* being in very small number.

For the foregoing readings canes were examined in lots of eight replications, each replication covering the same amount of area for each of the two varieties examined. The data are being worked out statistically and the result will be published in due course.

In view of the variable results which have been obtained so far at Pusa and elsewhere in India about the incidence of various pests on different varieties of cane, a randomized plot was laid out in February 1935 in Harpur Jhilli and planted with five varieties of cane, namely, Co. 210, Co. 213, Co. 299, Co. 313 and Co. 331, over an area of about four acres. A part of this area was planted with

setts previously treated with lead arsenate, copper sulphate, formaline and creosote. Detailed monthly readings of the seasonal history and incidence of various pests on different varieties both in treated and untreated plots are being taken. About four thousand canes of each variety are examined every month. The progress of the development of various borers as shown by the appearance of "dead hearts", on all varieties taken together, up to the end of June is tabulated below :

Months	Total no. of dead hearts. Per cent.	Dead hearts caused by stem-borers. Per cent.	Dead hearts caused by top-borer. Per cent.	Dead hearts caused by root-borer. Per cent.
April	5·42	0·33	0·21	4·88
May	5·49	1·79	0·34	3·35
June	9·38	4·36	2·31	2·71

It may be mentioned that all "dead hearts" caused by borers in the area in which the foregoing readings were taken were removed at the time of observation, therefore the figures given against each month are of the dead hearts which appeared during the month.

To compare the incidence of borers in February plantings with that in October plantings and ratoon crop one thousand canes of each of the two latter crops have also been examined during the last three months. The results are given in the following table :—

A statement of percentage of "dead hearts" in ratoon-crop, October and February plantings.

Month	February (1935) plantings.	October (1934) Plantings.	Ratoon crop.
April	4·30	10·8	..
May	7·5	11·0	9·4
June	17·45	26·0	24·90

It will be noticed that the incidence of borers in the October and ratoon crops even when grown in one of the best fields at Pusa, has been throughout much higher than in the February plantings. It appears that such crops in addition to getting heavily infested themselves act as source of infestation for February plantings, as they afford food to borers during the period between the harvest of old and the sprouting of the next crop. It will also be observed that there was very big increase in the number of dead hearts in all the three crops after May.

The egg-masses and adults of *Pyrilla* spp. were observed in small number up to the end of May, but practically no nymphs were seen up to that date, which indicates that the breeding of this pest was at a very low ebb during this period. This was obviously due to excessive dry heat, as in June, after a few showers, the pest started breeding both in the field and the laboratory.

In addition to the pests described above the following were found doing damage in the cane fields :—

The cane hispa *Asamangulia cuspidata* Maulik has been rather serious in all fields at Pusa since April. *Brumus suturalis* and *Myllocerus blandus* have also been met with in fair number. *Calocoris angustatus* F., *Monolepta signata*, *Formicomus* sp. and *Myllocerus 11-pustulatus* have also been found.

The sucking insects *Aleurolobus barodensis*, *Lepidosaphes* sp. and cane thrips *Anaphothrips citricinctus* Karny have also been fairly common. The morphology and bionomics of *Lepidosaphes*, a probable causative agent of the " yellowing disease ", has been investigated and a paper on the subject is under preparation for publication.

Trionymus sacchari increased abnormally in August 1934. *Assamia moesta* and *Aphis sacchari* were also common in August last year.

Parasites of various cane pests :—The eggs, nymphs and adults of *Pyrilla* spp. were found to be parasitized last year by the same parasites as in the previous years and the parasitism as usual was very high during July-December. This year up to the end of June the parasitism has remained low which is also usual.

The following parasites of other cane pests are recorded for the first time :—

The eggs of the root borer (*Emmalocera depressella*) have been found to be parasitised by the chalcid wasp *Trichogramma minutem* (Pl. IV fig. 1) almost throughout the year. This season parasitism remained 3-4 per cent. up to the end of May but during June it went up to 40 per cent. Each host egg generally contains three parasites. The parasite takes about 7 days to complete its life cycle in the laboratory in summer months. This parasite will be carefully studied during the rest of the cane season as it seems to have potentialities of proving useful if properly developed.

The larvae of *Emmalocera depressella* have been found to be parasitized by a braconid *Glyptomorpha deesae* and a bethylid wasp (Pl. IV figs. 7 and 8). The braconid is a powerful parasite but parasitism has remained 3-4 per cent. up to the end of June. The bethylid parasite appears in appreciable number (10 per cent.) in winter only when the root borers are full-grown and have already done damage to the canes. This parasite does not therefore seem to be of much practical importance.

The stem-borer *Argyria sticticraspis* has been found to be parasitized by *Apanteles flavipes* (Pl. IV fig. 4) late in the season. Last winter it was very common in all cane fields, actively moving about on leaves and stems in search of the holes of the borers through which it enters and parasitizes the borers inside. The number of parasites obtained from each borer varies from 40 to 80.

EXPLANATION OF PLATE IV.

Fig. 1. A Chalcid parasite (*Trichogramma minutum.*) of the eggs of *Emmalocera depressella* (× 72).

„ 2. The parasitized egg, highly magnified.

„ 3. Pupa of the parasite, dorsal view (× 72).

„ 4. *Apanteles flavipes*, parasite of the stem borer *Argyria sticticraspis* (× 25).

„ 5. A cocoon of the same (× 9).

„ 6. A cocoon mass of the same (× 2).

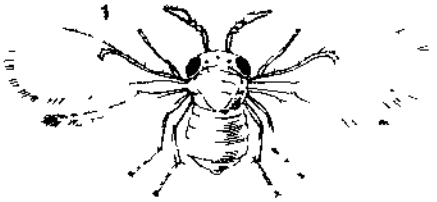
„ 7. *Glypotomorpha deesae* Cam., female (× 5), a parasite of the borer *Emmalocera depressella*.

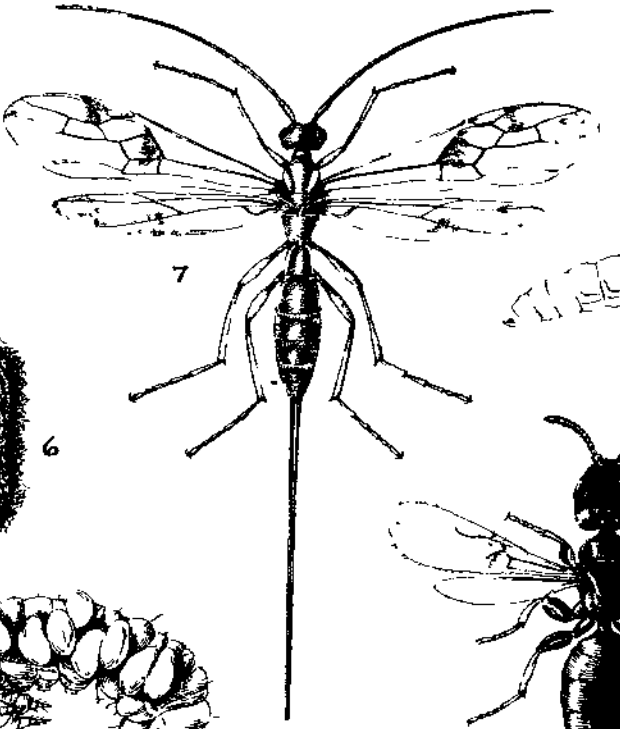
„ 8. A Bethylid parasite of the borer *Emmalocera depressella* (× 11).

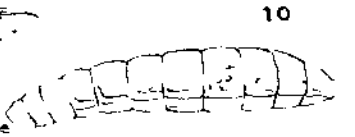
„ 9. The parasitized borer *Emmalocera*; note the parasitic larvae on the host.

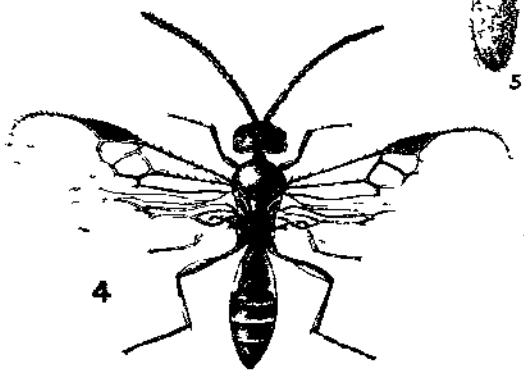
„ 10. Larva of the Bethylid parasite; magnified.

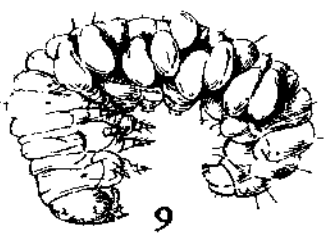
PLATE IV.

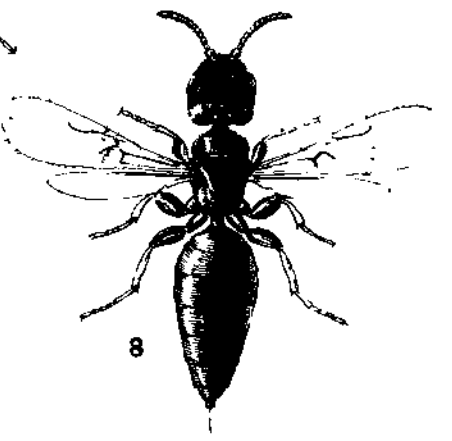












The morphology and bionomics of this parasite is also being studied in detail, as it might have potentialities of proving useful in the control of the stem-borer.

Insect vectors of "Leaf-curl" of Tobacco.—The leaf-curl disease of tobacco is on the increase at Pusa and other places in North India. It is believed to be a virus disease. Last autumn, in the Botanical area at Pusa the disease was noticed about three weeks after the crop had been transplanted. In the middle of November about 50 per cent. of the plants were reported by the Botanical section to be affected by this disease. In the end of December over 70 per cent. of the crop was found to be badly affected. In addition to leaves, the stems of many diseased plants were twisted and bent and the whole plants were stunted in growth. The amount of economic loss caused by the disease can therefore be easily imagined.

The Second Economic Botanist distinguished 4 or 5 types of the disease in his area last year and the diseased plants required for entomological investigations were kindly supplied by him. Moreover, the Imperial Economic Botanist placed at the disposal of the Imperial Entomologist a plot of tobacco for experiments and allowed his staff to make daily collections of and take observations on the Insect fauna in all his tobacco plots covering an area of about two acres. The valuable assistance thus rendered by the Botanical section is gratefully acknowledged.

In order to discover the probable insect vector or vectors of the disease a complete collection of the Insect fauna of both healthy and diseased tobacco was made at Pusa and in the neighbouring villages from the beginning of October up to the end of March when all plants of the crop were in flower and the vegetative growth was at an end. The collection was made from 6 A.M. to 10 P.M. and includes about 400 species of different insects, of which, of course, a considerable number appear to be only casual visitors of tobacco. Virus diseases as a rule are known to be transmitted by sucking insects only. Of such insects about 10 species were commonly met with on tobacco, but only two species, namely a Capsid bug *Engytatus tenius* and an Aphid, especially the former, were present on tobacco in large number throughout the season. In view of the limited amount of staff available for this work only one species, *viz.*, *Engytatus tenius* was selected for transmission experiments. For the same reason only the two common types of disease, designated as A and B, were selected for study.

Young and adult specimens of *Engytatus tenius* collected from the field were fed on diseased leaves enclosed in cellophane tubes for varying amount of time (12 hrs. to 5 days) and then introduced on healthy plants grown in pots and in the field and covered with wire-gauze cages and muslin bags since their germination. In this way about 75 plants were treated with A type and 50 plants with B type during December and January. In April when all bugs

were removed, about a dozen plants, mostly those treated with B type, showed an abnormal growth, but none exhibited the complete symptoms of the disease.

The bug cannot yet be declared "non-guilty", as the work was handicapped by the following drawbacks:—

(*a*) The work was started in the beginning of October (about a month after the Imperial Entomologist joined at Pusa) when the crop was already in the field and no stock of bugs bred pure was available. In the absence of such a stock stray specimens collected from field had to be used for feeding and transmission experiments.

(*b*) The properties of the virus concerned and the various stages in the development of the disease are yet not known. It is possible that the atypical growth mentioned above is an early stage in the development of the disease and that the next stage is caused by some other insect.

It is therefore proposed to continue the work on this bug and other suspected insects, especially the Aphid, next season if the scheme of work proposed to the Imperial Council of Agricultural Research gets sanctioned in time. In the meantime, the life-history and alternative food plants of *Engytatus tenius* and the Aphid are being studied and efforts are being made to breed pure stocks of these insects for transmission experiments next winter.

A New pest of Linseed at Pusa.—For the last few years a minute Cecidomyid fly has been observed to be doing damage to linseed flowers in the Botanical area at Pusa. In 1933 the damage by this pest was about 50 per cent. In February 1935 a special investigation of the bionomics and economic status of the fly was undertaken. This year the maximum number of affected flowers has been about 15 per cent. A series of specimens of the fly was sent to a specialist for identification and it has been declared to be a new species of *Dasyneura* and named as *D. lini* Barnes. The flies which are of beautiful orange colour are fond of sunshine and are most active during the brightest part of the day (11 A.M. to 3 P.M.). At this time they hover from plant to plant, laying eggs on the outside but often inside the flower buds. Young larvae hatched from the eggs laid on the outside also work their way in the buds. The larvae live on the stamens and other internal organs of the unopened flowers, which consequently present an emaciated appearance and in most cases do not open at all. The infested flower-buds can be easily recognized in the field by the crumpled appearance of the exposed portion of the corolla. It was found that the imported varieties of linseed (Australian) were more heavily attacked than the indigenous ones. Perhaps this differential susceptibility is connected with the different times of flowering. This point will be carefully investigated next year.

The larvae when full grown (on an average 7 days after hatching) come out of the buds, drop in the soil and pupate. The pupation period lasted 4-7 days in the laboratory in which the temperature varied from 70°F. to 82°F.

In view of the proposed extension of linseed cultivation in India it is feared that this pest is likely to become of major importance in future.

Pests of Stored grains.—The common grain weevil, *Calandra oryzae* exhibits great variations in its bionomics and life-history in various parts of the world, presumably due to varying conditions of climate. A detailed study of the influence of different temperatures and humidities on this weevil has been undertaken. The common dessicators were improvised as the humidity jars and special stands to take about a dozen rearing tubes which can be rapidly put in and taken out of the jars, were devised and got locally made at a low cost. The complete apparatus is working very satisfactorily. It took some time to devise and fit up the apparatus, the observations on the biology of the weevil therefore have yet been taken for a short time only. It appears that the weevil if kept at humidity below 60 per cent does not lay eggs and even if a few eggs are laid, they do not hatch at all.

Alongside the biological investigations mentioned above a study of the repellant action of some cheap country materials on the weevils was started last autumn. The weevils under experiment have not yet passed through any monsoon season during which they are known to propagate most, the final readings therefore will be taken in October or November and results reported in due course.

Pests of Fruits and fruit trees.—The important pests of fruit at Quetta and the neighbouring districts have been under observation during the summers of 1932, 1933 and 1934. Several notorious pests prevalent in other countries, *e.g.*, the Codling moth, San Jose Scale, etc., have been found to occur in this area. A brief account of these pests was given in the reports of the years named above, but a comprehensive paper on the subject has been under preparation during the year under report. Similarly a paper giving a brief account of the common fruit pests of N. W. F. Province has been prepared.

Jassidae (Rhynchota).—In view of the importance of Jassidae as pests of various crops and transmittors of some virus diseases, a collection of the species of this family occuring at Pusa has been made since the spring of this year. The collection has already yielded several novelties. A paper describing these novelties together with those from other parts of India has been prepared and will be shortly submitted for publication.

Life histories of Indian Insects.—The study of the life-histories and habits of insects doing damage to economic or wild plants was

continued. The immature stages of those which proved to be of special interest were figured and illustrated. Altogether about 80 insect species have been studied during the year under report, of which the following are of special interest:—Larvae of *Tischeria ptarmica* mining leaves of *Zizyphus jujuba* reared up to the adult stage for the first time; caterpillars of *Mabra eryxalis* Wlk, *Cnaphalocrocis medinalis* Guen. and *Mocis frugalis* Fab. found feeding on leaves of paddy. The bionomics of two Braconid parasites of the larvae of *Sphenarches caffer* and the vine leaf caterpillar *Sylepta lunalis* have been worked out.

The life-history of a species of *Tabanus* has been studied in detail. It is an active blood sucker of cattle. The eggs are laid in packets of about 850 each on the leaves of *Rumex nepalensis* growing near water. There is only one brood in the year.

To determine the number of broods in a year of the common *Metacanthus pulchellus* Dallas, rearing on a large scale of the bug was undertaken last spring. From the beginning of February up to the end of June the bug completed six generations.

IV. OBSERVATIONS ON OTHER INSECT PESTS.

The following important pests of various crops occurred again in Pusa:—*Sylepta lunalis* Guen. was bad on grape vines during July. It was successfully controlled by spraying with lead arsenate. *Dichocrocis punctiferalis* Guen. was found in numbers in guava fruits and castor capsules. Aphids appeared on various cultivated crops. In some cases they were kept in check to a certain extent by the presence of *Chilomenes sexmaculatus* and other Coccinellid beetles, in other cases they were successfully controlled by spraying with nicotine sulphate. The coccinellid beetles were found to be parasitized by numerous Chalcid parasites. *Agrotis* spp. appeared on tobacco, potato, gram, carrot, beet and turnip plants. They were controlled by hand-picking and baiting. *Euzophera perticella* Rag. was found breeding on brinjal stems. *Leucinodes orbonalis* Guen. was found boring brinjal shoots and fruits. *Pempheres affinis* Fsh. was present in numbers in the stems of old American cotton, the Aligarh white and the Punjab F. 49 cotton in September 1934. *Idiocerus* spp. were present in numbers on young mango plants, mango leaves and flowers. Spraying with rosin compound, when the plants were not in flower, was found effective against them. *Nupserha bicolor* Thoms. occurred on soybeans in July. *Pulvinaria psidii* Mask. was bad on young grafted mango plants. It was successfully controlled by spraying with rosin compound. *Dysdercus cingulatus* Fb. was found in large numbers on cotton and *bhindi* throughout the season. *Plutella maculipennis* Curt. was common on cabbage and cauliflower from November to March. *Arytaina (Psylla) isitis* Buckt. occurred on indigo leaves. *Euchrysops cnejus* Fb. damaged flowers and pods of *cajanus indicus* and *mung*. *Aulacophora abdominalis* Fb. was

bad on cucurbit plants. *Exelastis atomosa* Wlsm. was found boring into the pods and eating the seeds of *cajanus indicus* during April. *Papilio demoleus* Linn. damaged citrus leaves. *Earias fabia* Stoll. was found boring the pods and young shoots of *bhindi*. *Laphygma exigua* Hb. infested lucerne leaves. *Monophlebus* sp. was noticed to be present on mango, *mahua*, *siris* and jack trees. Tur-pod fly was found in pods of *cajanus indicus*. Fruit flies were found attacking various cucurbit and other fruits, such as *Karaela*, *phoont*, cucumber, melons, *aegle marmilos*, sapota, peach, etc. *Sesamia* sp. was observed boring into the maize stem and causing 'dead hearts'. *Margaronia indica* Saund. infested leaves of melons and some other cucurbit plants. *Trabala vishnu* Lef. on leaves of *Quisqualis indica*.

The damage by the following major pests of crops was not appreciable during this year at Pusa:—*Diacrisia obliqua* Wlk., *Maruca testulalis* Geyer, *Heliothis obsoleta* Fb., *Utetheisa pulchella* Linn., *Cirphis unipuncta* Haw., *Spodoptera mauritia* Bisd., *Achaea janata* Linn., *Pieris brassicae* Linn., *Etiella zinckenella* Tr., *Nephotettix bipunctatus* Fb., *Nephotettix apicalis* Mots., *Nodostoma subcostatum* Jac.

The occurrence of the following insects in Pusa on the hosts indicated is noteworthy:—*Prodenia litura* Fb. on berseem leaves; *Engytatus tenius* on leaves of bottle gourd: *Virachola isocrates* Fb. larvae boring into the fruits of *litchis*: some Gracillariad caterpillars mining the leaves of *Bassia latifolia* (May 1935); *Mabra eryxalis* Wlk. on leaves of paddy. *Chauliops* sp. was found in numbers on soy-bean during July. *Tischeria ptarmica* Meyr. was reared in Pusa for the first time in 1934 from larvae mining leaves of *Zizyphus jujuba*.

V. INSECT SURVEY AND COLLECTIONS.

Due to frequent shiftings consequent on the earthquake of last year and subsequent unsatisfactory condition of storage for want of space, the valuable insect collections of the Section got badly mixed and damaged. In October when more space became available, the poisoning of the collections and weeding out of pins and damaged specimens was started. This work together with the re-arrangement of the mixed collections took about four months. Then the proper registration (for which special registers were got printed) and card cataloguing of the collections was undertaken. This is a very formidable work indeed. About one thousand species, comprising about 20,000 specimens have been catalogued so far and it will take about a couple of years to make the registers and card catalogues up to-date. The registration of the collections is very essential so that we may have a complete record of what we possess. The utility of the card catalogue need hardly be emphasized. When completed it will be a very useful source of reference for the food plants, seasonal and regional distribution of the Insect fauna of India. It is proposed to publish a series of bulletins on

this subject so that the data may be readily available to the Provincial entomologists and other workers for use in connection with their economic or systematic work.

A large number of insects occurring at Pusa were collected to fill up the lacunae in the collections, which were furthermore enriched by the addition of about one hundred named species, some of which were received from Government Entomologists of the Punjab, Madras and Mysore by exchange or presentation.

The following lots of specimens were received back after naming and were incorporated in the collections. The assistance rendered by various specialists in this connection is gratefully acknowledged :—

(*a*) Coccidae of Baluchistan ; from Mr. F. Laing, British Museum, Natural History, London.

(*b*) Aleyrodidae (white flies) ; from Mr. K. S. Lamba, Lecturer in Zoology, Science College, Nagpur.

(*c*) Cecidomyidae on linseed, Pusa ; from Dr. H. F. Barnes, Rothamsted Experimental Station, Harpenden.

(*d*) Fruit Pests of N. W. F. P., including slides of Aphidae ; from the Imperial Institute of Entomology, London.

(*e*) Microlepidoptera ; from Mr. T. Bainbrigge Fletcher, Gloucestershire, England.

(*f*) Ephemeroptera including three new species ; from Indian Museum, Calcutta.

Several lots of unnamed specimens of Mites, Aphidae, Termites, etc., were sent to the Imperial Institute of Entomology, London, for favour of identification.

VI. ADVISORY AND MISCELLANEOUS.

Insect Pests : Fifty-nine parcels of insect specimens (comprising about 200 species), received from various parts of India during the year were examined and identified as far as possible. In the case of pests suitable control measures were suggested.

Information regarding the control of Termites and some important pests of sugarcane, stored grains, and other crops was supplied to over thirty different enquirers.

Advice regarding the preparation and use of insecticides, and about the preservation of insect specimens was given to five different correspondents.

Samples of leather treated with camphor oil, received from Messrs. Garnar & Sons, London, and about twenty samples of wood treated with a proprietory chemical by the Imperial Chemical Industries, Limited, were tested against the attack of termites.

Information about the parasites and predators in India of the Australian sheep Blow fly and the Buffalo-fly was supplied to the

Council of Science and Industrial Research, East Melbourne, Australia.

The potato and other experimental plots of the Imperial Economic Botanist, Pusa, were on several occasions sprayed or otherwise treated against aphids, termites, cutworms, rats, etc.

All entomological work for the Bihar and Orissa Department of Agriculture was attended to.

Fly and mosquito campaign was carried on throughout the year on the Pusa Estate.

Examination of Research papers, Schemes, etc.—Notes on about half dozen subjects were prepared and submitted to the Imperial Council of Agricultural Research. Seven research papers received from the Imperial Council of Agricultural Research, the Indian Lac Research Institute, Ranchi, the Zoological Survey of India and the Department of Zoology, University of Lucknow, were gone through and reported on.

The Second Entomologist visited Hyderabad to advise the Agricultural Department about the reorganization of their Entomological Section.

Issue of Certificates, etc.—Twenty-two samples of various seeds from the Imperial Economic Botanist, and the Imperial Agriculturist, Pusa, were fumigated and necessary certificates issued.

Bee-Keeping.—Information regarding Bee-Keeping was supplied to numerous enquirers. Standard bee-hives were got made locally for several applicants; queen-excluders and comb-foundation sheets for *Apis indica*, prepared in the Entomological laboratory at Pusa were supplied to fourteen different correspondents.

Coloured plates, etc.—A coloured plate of the Apricot chalcid fly was prepared and lent to the Director of Agriculture and Allied Departments, N. W. F. Province, Peshawar, for making lantern slides for campaign against this serious pest in his province.

About 400 coloured plates of different pests were supplied to various provincial entomologists, educational institutions and private individuals.

Donation of specimens—

23 specimens of Calliphorinae to Prof. W. S. Patton, Liverpool.

23 specimens of Diptera to the School Health Officer, Agra.

5 specimens of *Pempheres affinis* to Government Entomologist, Madras, Coimbatore.

150 specimens of Ticks to the Imperial Institute of Veterinary Research, Muktesar.

Two lots of Ephemeroptera and Odonata to K. A. Rahman, Zool. Lab. Cambridge, England.

34 specimens of Rhynchota, Ephemeroptera and Odonata to Prof. C. Strickland, School of Trop. Med., Calcutta.

Specimens of six species of Aphodiinae to Imperial Institute of Veterinary Research, Muktesar.

Specimens of important Insect pests of crops to Dr. J. K. Dubey, State Agricultural Department, Bhopal.

Loan of named specimens :—

Choenobius bipunctifer & Etiella zinckenella to the Prof. of Entomology, Agricultural College, Cawnpur.

Ichneumonidae to the Government Entomologist, Madras.

Specimens of Codling moth to the Agricultural Officer, Baluchistan, Quetta.

Dr. W. B. Gurney, Entomologist to the Government of New South Wales, visited the Section in June 1935 to discuss with the Imperial Entomologist the possibilities of importing a suitable Indian parasite of fruit flies into New South Wales. He consulted the collections and scientific records of the Section pertaining to fruit flies and other Indian pests.

Rai Sahib G. R. Dutt, Entomologist, C. P., Nagpur, worked in the Entomological Section for one week and consulted its Insect collections.

VII. PROGRAMME OF WORK FOR 1935-36.

This will follow generally on the lines of work of the previous year and will include special investigations of the pests of sugarcane, tobacco, fruit-trees, linseed and stored grains. An investigation of the biological standardization of various Insecticides will be started. Results obtained in various lines of work during the previous years will be written up for publication. The card catalogue of collections will be proceeded with. Advice and assistance will be given as far as possible to Provincial departments and to all enquirers on entomological subjects.

VIII. PUBLICATIONS.

Lists of publications on Indian Entomology for the years 1930, 1931, 1932 and 1933 were seen through the press and the List for 1934 was prepared and submitted for publication to the Imperial Council of Agricultural Research.

A paper entitled "Life histories of some Indian Thyrididae (Lepidoptera)" by B. B. Bose, Assistant, was submitted for publication.

REPORT OF THE IMPERIAL DAIRY EXPERT

[ZAL R. KOTHAVALLA, B.AG., B.SC. (AGRI.), N. D. D.]

I—INTRODUCTION

I held the post of the Imperial Dairy Expert throughout the year.

With the de-commercialisation of the farms at Bangalore and Karnal more attention is now being paid to the development of the other scientific and research activities. The transfer of a Chemist from Pusa to the Bangalore Institute has further added to the utility of the Institute, as besides the analytical work done in the laboratory the teaching efficiency of the students will be enhanced.

An evidence of the interest aroused in the public in the dairy industry is the increased number of inquiries received and the advice sought by them from the Imperial Dairy Expert's office. Two outstanding features of these inquiries were that some of the well-known cattle breeders of the country who were wanting their herds solely for the purpose of producing draft cattle have now turned their attention to the production of milk and requested for schemes to run their cattle breeding farms on dairy lines realising that with the changing conditions and the decreasing demand for purely draft cattle, organisation of the dairy industry must precede any efforts at cattle improvement in future. Another sign of the times is that most of the inquiries received from purely business men in the dairy line pertained to factory methods of handling milk and milk products and to knowledge and experience to be had in the manufacture of products like condensed milk, milk powder, etc. in order to utilise by-products like separated milk, butter milk, etc. which at present are more or less wasted. Material for helping the public in this direction is very limited at present and facilities for imparting training in such methods are more or less limited; so the new Imperial Research Creamery at Anand which has now been sanctioned will fill a long standing need for the development of industrial dairying in this country.

Karnal Farm—The receipts of the farm during the year under review were less than the previous year by Rs. 13,856. This is accounted for by the sale rates of agricultural produce being lower than last year as also to the curtailment of farm cultivation operations owing to 118 acres of land which were under farm cultivation having been transferred to the Agricultural Section of the Imperial Institute of Agricultural Research. Rainfall during the year was normal. The breeding of pure bred Tharparkar and Hariana types of cows with a view to effect an improvement in their milk yield was continued during the year. The results so far achieved are that

the overall (dry period included) average yield during the year works out from farm-bred Tharparkar at 9.1 lb. and for Hariana 8·8 lb. as compared with the foundation stock purchased in 1923 when the overall average for both breeds worked out to 5·6 lb. There were no notable outbreaks of contagious diseases in the herd except a mild attack of Surra which was promptly brought under control. The mortality amongst the herd was normal.

Bangalore Farm—There was a reduction of Rs. 16,344 in the receipts of the farm as compared with the previous year due to the fall in the demands of milk from the British hospitals and the transfer of 14th Brigade from the station. The increased expenditure of Rs. 3,821 over the previous year is accounted for by the transfer of a Dairy Chemist from Pusa to take charge of the dairy laboratory at Bangalore and to higher rates paid for *ragi* straw, owing to the failure of rains in the season. The overall average during the year was 9·0 lb. for cows and 9·4 lb. for buffaloes. The health of the animals was good and the mortality amongst the herd was normal.

Wellington Farm—In spite of the reduction in the sale rates of dairy produce the farm worked at a profit of Rs. 6,690 during the year. Although the receipts were Rs. 1,247 less than the previous year there was an increase in the quantities of milk and butter sold during the period *i.e.*, milk 30,508 lb. and butter 1,061 lb. The outturn of farm crops was lower than the previous year due to less rainfall. The overall daily average of cows was 16·61 lb., *i.e.*, much more than Bangalore because only half bred cows from the Bangalore herd which are heavy milkers are sent to this place. The health of the animals was good except for some cases of abortion. This disease has been prevalent at Wellington for some years and the local veterinary authorities are doing their best to investigate the causes. Lately the veterinary authorities at Muktesar were also approached and the Director, Muktesar Institute is also investigating into the matter.

II—TRAINING AND EDUCATIONAL WORK

Out of the 21 students admitted to the Indian Dairy Diploma course in October 1933, 20 students continued to take the course. One repeat course student who failed at the Allahabad Institute in the last Indian Dairy Diploma examination was admitted on 1st June 1935. Three post-graduate students who were admitted to the course in January 1934 completed their training in March 1935. Of the two students who were admitted to the post-graduate course in January 1935, one left for Scotland for higher studies. Of the four short course students who were admitted for training during the year, two completed the course and the remaining two are continuing during the current year. Those who completed the training took a short course of post-graduate character. 15 British

soldiers admitted to the vocational training on 2nd February 1934 completed their training on 31st July 1934 and a fresh batch of 12 soldiers admitted on 1st August 1934 also completed the course on 31st January 1935. Another batch of 13 soldiers taken in April 1935 is continuing the training during the current year.

There was no examination of the Indian Dairy Diploma students at Bangalore this year as students are taken every two years, but an examination was held in December 1934 of the Allahabad students at that Institute and out of seven students who appeared five passed including one repeat course student from the Bangalore Institute.

III—ADVISORY AND PROPAGANDA WORK

Advisory work forms one of the main functions of this office, and during the year under review, advice was given on dairying and cattle-breeding and allied subjects to individuals, associations and Government officials in the following Provinces :—

Bombay Presidency	9
Madras Presidency	8
Bengal Presidency	11
United Provinces	11
Punjab including Kashmir and Malerkotla	13
Mysore State	2
Burma	4
Assam	1
Central Provinces	3
Malacca	1
Bihar and Orissa	2
Malay State	1
Coorg	1
	67

The above advisory enquiries emanated from the following sources :—

Government officials	13
Private individuals	39
Firms, associations and other organisations	15
	67

IV—EXPERIMENTAL AND RESEARCH WORK

The systematic selective breeding work of indigenous cattle, *viz.*, the Hariana and the Tharparkar breeds and the buffaloes at the Imperial Cattle Breeding Farm, Karnal and the Scindi and Gir breeds and buffaloes at the Imperial Dairy Institute, Bangalore, was continued during the year. All the breeds have shown considerable improvement in type, conformation and performance.

The testing of milk of individual animals for fats and solids-not-fat from day to day was continued both at Karnal and Bangalore, and the statistics are being compiled from the tests on record.

Feeding experiments on the comparative effects of high and low protein rations to milch cattle were continued during the year in co-operation with the Physiological Chemist.

Other items of investigation carried out at the farms were as under :—

1. Systematic investigation work for standardising the method of making *Surti* cheese—one of the soft varieties of Indian cheeses.

2. Comparative study of the efficiency of sterilisation of dairy utensils and milk bottles by steam, catadyn water, and chemicals.

3. Study on the cultivation and yields of Guinea, Napier and lucerne grasses as fodder crops.

4. Study on the making of a barrow for carrying cans of milk.

5. Cheese experiments to study the relation of fat per cent. on milk to yield and quality of cheddar cheese.

6. Study of keeping quality of milk under different conditions such as milk at ordinary air temperature and in the cold stores; also raw, chilled raw, pasteurised, heated or boiled, etc., to find out the best way to lengthen its life.

7. Comparative study of the efficiency of hand milking *versus* machine milking.

8. Study of the correlation of some points in body conformation with milk yield in Indian cows.

9. Body measurement and weight of cows in relation to milk yield.

10. Keeping quality of milk in relation to the kinds of vessels used, *e.g.*, of earth, glass, enamel, porcelain, etc.

11. Physical characteristics of fat in the milk of the various breeds of Indian cattle, both cows and buffaloes determined microscopically.

12. Prenatal treatment of heifers and cows to increase their milk yield and to facilitate easier handling when first coming into milk.

V—PUBLICATIONS

An article on "Indian buffaloe as a milch animal in tropical countries" by Mr. Zal R. Kothavalla was submitted for publication in "Agriculture and Livestock in India".

An article "Study of the various standards adopted for the examination of Indian butter and ghee" by Messrs. S. D. Sunawala of the Indian Institute of Science and Zal. R. Kothavalla, was submitted for publication to the Imperial Council of Agricultural Research.

VI—CO-OPERATION WITH OTHER SECTIONS AND DEPARTMENTS

This section fully co-operated with the Physiological Chemist's Section in providing it with facilities required for its experimental work in the form of cattle, feed, etc. Also the help received from that Section in conducting various experiments, analysis of food stuffs, etc. is much appreciated.

Thanks are due to the Mysore Civil Veterinary Department for arranging to protect the Bangalore herd against Rinderpest by the S. S. method inoculation free of charge. The Director, Imperial Institute of Veterinary Research, Muktesar, arranged for the inoculation of a large number of calves against Rinderpest by goat virus alone method. This method while being entirely safe has also proved to be more economical compared with the S. S. method. The help given by the Muktesar Institute is greatly appreciated.

VII—ADMINISTRATION OF FARMS

The following detailed reports from the Superintendents of farms are submitted. These reports have been commented upon in the introduction to this report.

Bangalore.—During the year 1934-35 the office of the Superintendent of this Institute was held by Mr. S. Cox.

The outturn of green fodder from the farm lands was very low as compared with the previous year. The outturn during the year was only 16,65,303 lb. as against 27,81,732 lb. in last year. The reduced outturn was mainly due to the failure of the monsoon thereby increasing the cost of production. The average rainfall at Bangalore used to be about 35 inches as recorded in this office but the rainfall for this year was only 21 inches and half of this fell in November 1934 when it was too late for the *Jowari* crop.

There was a drop in the sales of milk by 20,321 lb. as compared with last year's sales. This was due to less demands from the Military Hospitals during this year, as also to the removal of the 14th Field Brigade from this station. Wellington Institute was also supplied with 5,360 lb. milk during the year. There was however an increase in the sales of butter by 1,816 lb. and cream by 331 lb. due to the reduction in the rates of dairy produce introduced from 1st August 1934.

As this Institute has been decommercialised since 1st April 1933 and is now purely an educational and research institute, no financial accounts were prepared.

1. *Expenditure.*—A comparison of figures for three years is given below :—

1934-35.	1933-34.	1932-33.
Rs. A. P.	Rs. A. P.	Rs. A. P.
1,19,314 7 9	1,15,493 6 5	1,29,193 0 6

The increase in expenditure during this year was due to the creation of a post of Dairy Chemist who was transferred from Pusa and to the increase in the cost of *Ragi* straw purchased owing to the failure of monsoon.

Receipts.—Comparative figures for three years are given below :—

1934-35.	1933-34.	1932-33.
Rs. A. P.	Rs. A. P.	Rs. A. P.
76,082 3 11	92,426 7 9	1,16,560 10 3

The decrease in the receipts was due to less sales of milk and also to the reduced sale rates for dairy produce for 8 months in the year.

Sale rates of Dairy produce.

	1934-35. Per lb. Rs. A. P.	1933-34 and 1932-33. Per lb. Rs. A. P.
Milk		
Officers, Civilians, Troops and Hospitals	0 3 0 *0 2 0	0 3 0
Married families	0 2 6 *0 2 0	0 2 6
Issues at the Dairy in customers own vessel	0 2 6 *0 2 0	0 2 6
Bulk for 50 lb. and above issues at the Dairy in customers own vessel	0 2 0	0 2 0
Bulk for 25 lb. and above issues at the Dairy in customers' own vessel	0 1 6	..
Butter		
Officers, Civilians, Troops and married families	1 4 0 *1 0 0	1 4 0
Civilians (from 5th February (*a*) 1933 to 31st May 1934)	1 8 0 & (*a*) 1 4 0 *1 0 0	1 8 0
Cream		
Officers, Civilians, Troops and Married families	1 12 0 *1 0 0	1 12 0
Cheddar Cheese		
Whole cheese	1 4 0 and 1 0 0	1 4 0
On cut	1 8 0 and 1 4 0	1 8 0

Establishment—The expenditure under this head for three years was as follows :—

1934-35.	1933-34.	1932-33.
37,605 14 0	34,974 5 0	32,834 4 0

The excess expenditure during 1934-35 was due to the transfer of the Dairy Chemist from Pusa, and the employment of an extra Supervisor in connection with the vocational training of British soldiers.

*Rates reduced from 1st August 1934.

Cultivation—The same policy as in the past continues, *i. e.*, to keep under permanent green crop as much land as the water available for irrigation permits. This consists of about nine acres of Guinea grass, half an acre of Rhodes grass and two-thirds acre of lucerne. These crops usually give a continuous green fodder supply throughout the year, but during the year the outturn was less owing to the failure of monsoon.

The remaining cultivation area of about fifty-four acres is used annually for a monsoon crop, usually *jouari* which is utilised largely for silage making.

The only fodder purchased continually is *Ragi* straw, a crop which is not grown on the Farm. It could be grown but only at the sacrifice of *Jowar* which gives much heavier outturn. The outturn, etc. of fodder crops for the last three years are shown in the statement attached.

Three plots were sown to mixed maize and oats as a winter crop under irrigation and they were found to be a great success.

Several new kinds of grasses such as Teosinte, Sudan grass, Napier fodder, Paspalam, Italian Rye and Kulakuttai are being tried in experimental plots for the purpose of seeing their utility as well as for educational purposes. The I. D. D. students look after these plots.

Cattle—The herd maintained consists of crossbred cows, (*i.e.* those sired by imported Ayrshire bulls), Scindies, Cirs and Murrah buffaloes. To increase the foundation stock of Gir Breeding, 7 Gir cows and one Gir Bull were purchased during the year.

The feeding of the adult herd is based on the starch equivalent contained in the mixed concentrates which consist of bran, groundnut oil cake, brewery grains, gram chunni and cotton seed oil cake meal in the proportion of 4 : 2 : 2 : 1 and 1. A pound of this mixture has a starch equivalent of ·58 and the albuminoid ratio works out at 1 : 4·9. Based on the live weight of 700 lb. and giving milk of 4·2 butter fat a cow gets ·26 starch equivalent per pound of milk yielded *plus* 3/4 lb. of oil cake for maintenance. Roughages are fed on a basis of 18 lb. dry matter fed as green fodder, silage or dry *ragi* straw in whatever proportions they are available.

The comparative overall averages of milk per day of all animals in the adult herd were as follows :—

	1934-35	1933-34	1932-33
	lb.	lb.	lb.
Cow (X Bred, Scindi and Gir.)	9·0	8·3	9·6
Buffaloes	9·4	6·8	11·6

The increased figure for this year as compared with last year was due to more young stock having been transferred to the adult stock, *i.e.* 47 against 21 in the last year, and also to the increase in the milk yields of these cows. There would have been a further

increase in the milk average had it not been for the transfer of certain good milkers to Wellington Institute in place of dry animals returned from there.

The increase under buffaloes was due to the increase in the yield of 8 young buffaloes transferred from Karnal.

The following figures show the merit of the different classes of animals.

	X Bred.	Scindi.	Gir.	Buff.
Average daily number in herd milking	51·1	43·9	8·4	7·3
Ditto dry . . .	18·1	33·0	6·6	4·4
Average milk yield per animal which completed its yield during the year in lb.	4593·6	2758·5	2594·7	5089·2
Average number of days in milk of the same animals . . .	328·4	254·9	270·3	324·2

As the breeding policy is to improve the Indian breeds and to do away with the cross-bred herd gradually, the Scindi and Gir cows are crossed only by selected bulls of their respective breeds. Half of the ½-bred cows (good milkers) are served by Ayrshire bull and the other half by pedigreed Scindi bulls and so also in the case of ½-bred young stock. 3/4 Ayrshire or Hol. Scindi and Sahiwals are served by pedigreed Scindi Bulls and ¼-bred Ayrshire or Hols. Scindi are served by Ayrshire bull.

Of the 25 cows and 56 young stock (male and female) sold during the year the majority were of cross-bred type.

The quantities of milk produced were :—

	lb.
Cows	5,27,916
Buffaloes	40,881

Young Stock—The number of farm-bred heifers which joined the adult herd during the year was as follows :—

Cross Bred	31
Scindi	16

Rearing of Calves—The number of calves born at this Farm during the year was as follows :—

	Cow Y. S. Female.	Cow Y. S. Male.	Buffaloes (Murrah) Male.	Buffaloes (Murrah) Female
Scindi	31	43	6	2
X Bred	42	47		
Gir	2	6		

The male calves dropped by corss-bred cows are given away soon after birth and the number so disposed of was 41. Of the remainder cross-bred calves, 2 male calves and 6 female calves were sold and 7 female calves died. Calves of Indian breed are reared for stud purposes and for the purpose of improving the Indian breed. Calves of cross-bred animals are weaned at birth and also Scindi and Gir heifers. All such calves are hand reared commencing with a ration of new milk and later supplemented by separated milk and grain rations.

Diseases—There was no outbreak of contagious diseases during the year. The casualties were small when compared to last year. The deaths during the year 1934-35 were as follows :—

Country cows	5
Cross-bred	4
Cow Y. S. female	21
Cow Y. S. male	5
Buffalo Y. S. female	1

The adult animals died from various causes, such as Broncho-Pneumonia, Heart failure, Impaction of the third stomach and expulsion of uterus, etc., and the young stock died of diarrhoea, dysentery, etc.

The Institute was visited during the year by a large number of students from different schools and colleges.

Statement showing outturn of fodder grown on the farm lands during the year 1934-35 at the Imperial Dairy Institute, Bangalore, and the attached dry stock farm at Bommanpally with figures for 1932-33 and 1933-34

Where grown	1934-35			1933-34		1932-33	
	Kind of fodder	Acreage	Outturn in lb.	Cost per 100 lb.	Outturn in lb.	Cost per 100 lb.	Outturn in lb.	Cost per 100 lb.
				Rs. A. P.		Rs. A. P.		Rs. A. P.
BANGALORE	Green *jowari*	53·87	6,20,620	0 6 3	12,06,400	0 3 4	15,60,340	0 2 2
	Lucerne	·79	65,398	0 9 1	84,427	0 5 9	96,448	0 4 11
	Guinea grass	9·49	16,04,660	0 4 3	11,90,965	0 2 9	9,68,480	0 3 2
	Rhodes	·41	3,040	0 6 1	54,560	0 2 4	79,600	0 2 3
	Napier grass		12,980					
	Maize and oats		41,280					
	Berseem		485					
	Sudan grass		5,240					
	Total	64·56	15,53,703	0 5 4	25,36,352	0 3 1	27,04,848	0 2 7
BOMMANPALLY	Green *jowari*	..	1,11,600	0 6 0	2,40,380	0 3 0	2,83,355	0 1 10
	Guinea grass	..	..	..	5,000	0 0 4	8,400	..
	Total	..	1,11,600	0 6 0	2,45,380	0 2 11	2,91,755	0 1 9
	GRAND TOTAL	64·56	16,65,303	0 5 4	27,81,732	0 3 1	29,96,603	0 2 6

Wellington—Mr. M. C. Rangaswamy, I. D. D., Supervisor was in charge throughout the year.

The working of the Institute resulted in a profit of Rs. 6,690 against a profit of Rs. 7,738 during 1933-34 and a profit of Rs. 6,629 during 1932-33.

The figures given above will show that the farm has continued to work at a profit during the year inspite of the reduction in the sale rates which were given effect to during the course of the year.

This is due to a considerable increase in the sales of dairy products to the Military and the general economies effected.

The rainfall during the year was considerably less than the previous years, both during *Kharif* and winter seasons. To add to this the falls were very irregular. The frost during the year was as early as November.

Rainfall compared for three years :—

1934-35	26·04
1933-34	41·25
1932-33	50·34

Capital—The following table shows the value of capital assets at the beginning and close of the year.

Particulars	Value on 1st April 1934	Additions during the year	Total	Condemnations and transfers	Depreciation	Casualties	Value on 31st March 1935
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Land . .	10,919	...	10,919	...	...	...	10,919
Buildings . .	84,759	316	85,075	...	1,216	...	83,859
Plant and Machinery . .	5,800	347	6,147	...	969	...	5,178
Live Stock .	1,050	250	1,300	215	...	130	955
	1,02,528	913	1,03,441	215	2,185	130	1,00,911

Receipts—The comparative figures of receipts for the last three years are set out in the table below :—

Produce	1934-35		1933-34		1932-33	
	lb.	Rs.	lb.	Rs.	lb.	Rs.
By sale of—						
Milk	1,50,199	22,121	1,19,691	22,451	1,34,966	26,060
Butter	16,976	17,729	15,915	18,507	17,706	22,138
Cream	543	700	529	927	430	753
Separated milk . .	53	3	150	9	410	14
Butter milk . . .	136	2	100	2	153	2
Cheese	88	94	...	...	...	...
Total .	...	40,649	..	41,896	...	48,967
Miscellaneous . .	...	1,967	...	2,040	...	2,247
Grand Total .	...	42,616	...	43,936	...	51,214

All the items of receipts show a reduction as compared with those of the preceding two years. This is due to the reduction in the sale rates of dairy produce during the course of the year. It

will be noticed that in spite of the increased sales of the dairy products as compared with the last two years the amount realised was lower owing to the reduction in the sale rates.

The following table shows the sale rates of dairy produce for the past three years :—

Produce	1934-35	1932-33 and 1933-34
	Rs. A. P.	Rs. A. P.
Milk to officers, troops, Regimental Institutes and Hospitals	0 3 3	
	&	
	0 2 0	0 3 0
Married families	0 2 6	
	&	
	0 2 0	0 2 6
Butter to all	1 4 0	1 4 0
	1 0 0	
Cream to all	1 12 0	1 12 0
	1 0 0	
Separated milk to all	0 1 0	0 1 0

The sale rates during the year under review were reduced on the understanding that the troops stationed at Wellington obtain their full requirements from the Wellington Institute. This had the desired effect as there was an increase in sales.

Establishment—Comparative costs of establishment for the last three years are shown below :—

Particulars	1934-35	1933-34	1932-33
	Rs.	Rs.	Rs.
Supervisor in charge	1,674	1,540	1,515
Permanent staff	4,048	4,034	3,461
Temporary staff	5,337	5,351	5,511
Total	11,059	10,925	10,487

The increase in the expenditure was due to the grant of annual increments to the staff and the reduction of the emergency cut in salary from 10 per cent. to 5 per cent. since the year 1933-34.

The following table shows the quantities of butter produced from purchased cream and the comparative prices per pound for the last three years :—

Years	Purchased quantity	Price	Home produced quantity	All-in-cost
		Rs. A. P.		Rs. A. P.
1934-35	10,990	0 12 0	420	3 8 6·65
	6,494	0 11 0		
1933-34	9,947	0 13 0	530	3 15 2·75
	5,273	0 12 0		
1932-33	15,957	0 13 7	1,805	4 9 7·04

(*a*) *Purchased butter*—The increase in the quantity purchased was due to more butter trade with the Military.

(*b*) *Home produced butter*—As the cost of producing home butter will always be more than the purchased butter, its manufacture is restricted to the minimum possible taking into consideration the varying demands for milk from the military.

It may be mentioned here that the all-in-cost of purchased and home butter both combined for the year works out to Rs. 0-13-7·31 against the selling price of Rs. 1-4-0 and Rs. 1 per pound prevailing during the year.

Cultivation—The table given below shows the particulars of land in acres owned and leased by this Institute during the year under review :—

Particulars	Land. Total acreage	Arable		Grazing	Forest for fuel	Buildings and roads	Leased out
		Perennials	Seasonal crops				
Owned . .	68·85	5·00	25·50	24·26	7·00	6·08	...
Leased . .	40·00	...	10·00	...	...	...	30·00
Total .	108·84	5·00	35·50	24·26	7·00	6·08	30·00

The following table shows how the arable land was distributed for cultivation and the rotation that was followed :—

Kharif	Acres	*Rabi*	Acres
Green grass, lucerne, Rhodes & guinea grass . .	5·00	Rhodes and guinea grass and berseem . .	5·00
Potatoes	4·50	Potatoes . . .	2·50
Jowar	12·75	Oats and peas . . .	10·25
Maize	9·25	Oats	21·75
Ragi	10·00	Ragi	2·00
Total .	41·50	Total .	41·50

Out of the 40 acres leased land only 10 acres were utilized by the farm for fodder crops and the balance of 30 acres which the farm could not make use of were leased out on cash rental for cultivation purposes. The supply of green fodder from the area sown was sufficient to meet the requirements of the farm.

Although the rainfall was considerably less than previous years, both *rabi* and *kharif* crops grew fairly well and in order to get enough green fodder, peas, horse gram and oats and peas mixed were also tried.

The table given below shows the comparative yields of crops for the last three years :—

Crops	1934-35 lb.	1933-34 lb.	1932-33 lb.
Rhodes and Green grass	77,265	1,37,270	1,38,555
Lucerne	3,260	5,001	15,435
Maize	92,550	91,500	1,08,990
Oats	76,970	48,300	58,140
Ragi	11,390	56,650	1,700
Gram	9,340	4,400	..
Jowar	1,01,650	1,44,700	1,26,655
Wheat	..	52,415	11,535
Berseem	1,845	3,510	..
Barley	..	17,700	..
Peas	1,150	..	..
Oats and peas mixed	55,870	6,150	..
Cow Peas	2,050	..	..
Mangolds	..	3,300	520
Bajra	..	..	19,900
Sun flower	..	..	2,400
Cabbage	..	..	8,800
Total	4,33,340	5,70,896	4,92,630
Potatoes (Cash crop)	47,368	58,500	33,384
Total	4,80,708	6,29,396	5,26,014

Jowar and maize are found to be the most suitable crops for the *kharif* season both for green issues and silage making and oats and oats and peas mixed for the *rabi* season. These crops give large yields and are economical to grow. During the year under review green fodder was produced at Re. 0-8-0·6 per hundred pounds against the market rate of about Re. 1 (One) per hundred pounds. Owing to the failure of monsoon the expenditure in raising the crops with irrigation etc. increased.

The growing of potatoes being beneficial to the farm, it was again tried both in the *kharif* and *rabi* seasons. It is very helpful in the elimination of weeds and thus the other crops thrive well and it is also a paying crop. During the year an outturn of 6,767 pounds per acre was obtained at a production cost of Rs. 1-13-9 per 100 pounds against Rs. 1-8-3 in 1933-34.

Cattle—This farm under orders of Government is considered as a depot, cows in milk being supplied from Bangalore to Wellington as required and returned to Bangalore when dry.

The table below gives a comparison of :—

(1) Milking average per diem per head of milking cows, and

(2) Overall average of the year with the figures of the preceding year—

	Milking average per diem per head of milking cow	Overall average
1934-35	18·65	16·61
1933-34	17·50	16·10

There is a slight increase in the average yield of cows per day.

The comparative production cost per pound of milk for the last three years is given below :—

	Per pound. Rs. A. P.
1934-35	0 2 7·9
1933-34	0 3 1·2
1932-33	0 2 9·9

The cost price of milk shows an improvement over those of the previous years. This is due to the increase in the yield of milk and other economies effected in the expenditure. It should also be noted that the production cost is worked out " all in costs " meaning that it includes all indirect charges such as audit fees, direction charges, leave and pension contribution and interest on capital. These charges for this year alone amounted to Rs. 5,322. These charges do not appear in the Cash Account but for purposes of production cost they are added to the Expenditure. The costs of production exhibited are therefore more than what they would be if the above charges are left out.

The general health of the herd was good throughout the year. There were cases of abortion amongst cows. The investigation work on these abortions was taken up by the Madras Veterinary Department and is still being conducted. The Director, Imperial Institute of Veterinary Research, Muktesar, is also investigating into this matter. All necessary precautions are being taken.

Karnal

Mr. A. Lamb proceeded on leave on 13th April 1934 and was relieved by Mr. Harnam Singh who remained in charge until 12th December 1934 when Mr. A. Lamb returned to duty again.

There were no great variations in the prices realized by the sale of surplus crops. Rates for dairy produce remained regular throughout the year.

The total rainfall for the year was about normal, *i.e.*, 31·43 inches, of which 26·9 inches fell in July and August. The expenditure and receipts for the last 3 years were as follows :—

	1932-33 Rs.	1933-34 Rs.	1934-35 Rs.
Expenditure	73,060	65,105	68,015
Receipts	48,921	43,336	29,480
Net Cost	24,139	21,769	38,535

The higher cost in 1934-35 is due to the land leased on cash rental being less in area and at a lesser rate; less outturn of *ziri* due to the area sown being less, extra temporary establishment employed from December to February, expenditure on special repairs to the Depot Minor, refund of rent caused by floods in 1933-34, and the number of trees sold being less. The comparative sale and purchase prices are given below :—

SALES

Crop	1933-34	1934-35
	Rs. A. P.	Rs. A. P.
1. Wheat . . . . . per maund	2 9 6	{ 2 7 2 2 7 3
2. „ Machine thrashed . . „	{ 2 7 4 2 6 1 }	2 6 7
3. „ „ „ . . . „	1 11 3	..
4. „ and gram mixed . . „	..	1 12 2
5. Gram . . . . . „	1 13 0	1 8 2
6. „ machine thrashed . . „	1 9 6	..
7. Rice (*ziri*) . . . . . „	1 9 5·4	1 10 4·165
8. Mustard seed . . . . . „	2 5 1	..
9. Wheat *bhoosa* . . . . . „	0 6 9	0 3 6

PURCHASES

Name of concentrates	1932-33	1933-34	1934-35
	Rs. A. P.	Rs. A. P.	Rs. A. P.
1. Bran . . per maund	1 8 11	1 14 11	1 13 2 per 100 lb. & 2 3 11 „
2. Barley . . „ .	1 9 4	1 7 0	1 13 3·2 „ & 1 15 10 „
3. Linseed cake . „	2 3 6	2 0 0	3 1 3 „
4. Salt . . „	2 12 10	2 10 9	3 10 0 „
5. Feeding flour . per cwt.	11 0 0	10 0 0	10 0 0 „

The usual annual depreciation of capital assets was the cause of reduction of capital as also the transfer of 118·17 acres of land to the Agricultural Sub-station.

The contract rate for surplus milk sold to a local contractor was higher than the previous year.

The comparative figures of sale rates of dairy produce are given below :—

	1933-34 Rate per lb.	1934-35 Rate per lb.
	Rs. A. P. Rs. A.	Rs. A. P. Rs. A.
Fresh milk retail	0 0 9	0 0 9
Fresh milk on contract . . .	0 0 5·85	0 0 7·2
Butter	1 0 0 to 1 4	1 0 0 to 1 4
Cream	0 12 0 to 1 0	0 12 0 to 1 0
Cream on butter outturn . .	0 9 6 to 0 10	0 9 6
Ghee	0 6 0 to 0 9	0 9 0
Separated milk	0 0 3	None sold.
Cheese	1 2 0	1 2 0

The cost of establishment compared with the previous year was as under :—

	1933-34	1934-35
	Rs. A. P.	Rs. A. P.
Pay of Officers	3,258 11 0	3,491 4 0
Pay of Establishment.		
Pay of Assistant Superintendent, Indian Supervisors, Accountant, etc.	15,857 1 0	16,420 15 0
Pay of Permanent non-pensionable establishment	1,418 8 0	1,444 1 0
Pay of temporary establishment	13,354 14 0	13,982 5 0
Leave salary	1,226 2 0	542 0 0
Total	35,115 4 0	35,880 9 0

The sales of dairy produce for the last 6 months of the year as compared with the previous year are shown below :—

This is the period during which butter is sent to Delhi twice weekly.

	Milk	Butter	Separated milk	Cream	Ghee	Cheese
From October 1933 to March 1934	2,993	2,238	..	445	1,489	30
From October 1934 to March 1935	2,044	809	..	3,030	14	..

The Military Farms Department resumed taking cream for butter making with the result that very little *ghee* was made.

Cultivation

This Farm possesses 1,981·5 acres of land under its control out of this, 89 acres are non-cultivable (waste land), 262 acres were leased on cash rent by public auction for grazing and cultivation for one year, 182 acres were reserved for grazing by Farm livestock, and 257 acres are occupied by roads and buildings.

118·5 acres were under home cultivation during the first half of the year but in the second half year the whole of that area was transferred to the Agricultural Section of the Imperial Institute of Agricultural Research for the establishment of an Agricultural Sub-station. 1,073 acres were leased out on ' batai ' system for one year from the usual date, *i.e.*, 15th June.

Rotation

Of the 118·5 acres under home cultivation as mentioned above about 61 acres were sown with *Jowar* for silage making and the rest remained fallow till it was handed over in October to the Agricultural Section.

Batai Plots 2, 3, 4 and 5 :—Half was put down to *Jowar* and the other half fallowed for wheat in the winter.

Batai Plots 6 and 7 :—Half was sown with rice and the other half remained fallow during the *Kharif* season for the purpose of ploughing for destruction of weeds.

Crops.—*Jowar* and Rice were the two *Kharif* crops. Home *Jowar* was harvested green mainly for silage making. During the cutting operations green *Jowar* was fed green and a small portion reserved for dry fodder. The total green *Jowar* produced was 24,18,817 lb. Of the *Batai Jowar* the farm share was sold by auction as a standing crop—it being too scattered about the farm to utilise it for farm purposes.

Plots 6 and 7 being low lying and largely under water in the monsoon are only used for rice during that season.

The monsoon commenced with a few very light showers at the end of June. The first heavy rain which fell on 2nd July was 7·86 inches. The rains stopped early giving very light showers in September and therefore all the area under *Rabi* was sown by canal irrigation and this was also too late as the Agricultural and Botanical Sub-stations were to be given preferential treatment in so far as canal irrigation was concerned.

The record of rain as obtained from the Botanical Sub-station rain gauge is :—

June	July	August	Sept.	Jan.	Feb.	March	April	Total for year
0·86	16·94	9·97	0·43	2·57	1·27	0·54	0·95	31·43

The wheat crop was not irrigated from the time of sowing until late in March owing to the main canal as well as the Depot Minor being closed for repairs. Light showers in January and February helped to some extent but with cloudy weather in March and April rust appeared and caused damage, the variety P. 111 in Plot No. 4 *Batai* being most affected

As the wheat-Punjab 8A had proved very susceptible to disease, its cultivation was abandoned and a number of Pusa wheat were grown. The outturn from various plots of different varieties are as follows and of which the farm share was one-half.

Plot	Area Acre	Variety P.	Outturn Mds.	Srs.	Average outturn per acre Mds.
2	43·2	80-5	481	16	10·12
3	43·3	80-5	403	14	8·14
4	52·8	111	410	12	6·16
5	47·2	120	496	36	10·4
	26·07	114	142	2	4·14
	23·5	165	215	4	8·10

The best variety was P. 80-5 both from the point of view of quantity and resistance to disease but being beardless it was ed by pigs and birds. P. 111 was badly damaged by rust while P. 114 and 165 were slightly affected. P. 120 was affected with flag smut. All yields, however, were very low due to the 'batai' system and the plots being in bad condition.

Gram and barley were sown after *Jowar* and rice and also after fallow in the rice plots (6 and 7). The low outturns of grain are partly due to disease in wheat and partly to early stoppage of monsoon and late sowing caused by the difficulty in obtaining water in time.

	Acreage	Outturn Mds.	Srs.	Average outturn
Wheat	285·30	2,321	14	8·14
Gram	486·27	4,452	9	9·16
Barley	188·69	1,173	7	6·20
Oats	69·71	487	26	6·96
Rice	279·26	3,605	21½	12·92
Green *Jowar*	61·6	2,426,074 lbs.		39,130 lbs.

Hay and silage making :—The first cutting of grass from Plot 8 was converted into silage and the second cutting into hay. In other grass areas the crop was scanty due to monsoon conditions already pointed out and only silage was made. The total produce was 934,722 lb. grass silage and 29,766 lb. hay. A comparative yield of crops for the last 3 years is shown below :—

	1932-33	1933-34	1934-35
	lb.	lb.	lb.
GRAIN			
Rice (*Ziri.*)	266,500	216,972	144,187
Wheat	301,760	157,604	161,242
Oats	..	4,510	27,388
Gram	469,042	285,442	286,155
Mustard	3,280	..	..
Wheat and gram mixed	..	..	479
Barley	..	..	7,097
FODDER			
Green *Jowar*	276,164	16,200*	64,257
Dry *Jowar*	..	39,770	5,800
Green oats	..	..	12,352
Green maize	40,857	..	..
Dry maize	7,180	..	..
Gram stalks	..	..	87,022
Hay	118,476	227,332	29,766
Bhoosa (gram, wheat, barley and oats.)	698,694	652,909	518,697
Rice straw	272,404	215,250	138,150
Charri silage	1,551,840	940,836	1,765,920
Grass silage	168,388	364,300	718,912(a)
Anjan grass seed	53	..	9½
Grass fed green	14,378	..	..
Poolas (Thatching grass)	6,601	..	..

* Major part sold standing.
(a) 215,810 lb. overestimated—not included.

Cattle Breeding

Livestock figures at the beginning and end of the year were as follows :—

	1st April 1934	31st March 1935
Cows	129	146
Buffaloes	15	9
Cow bulls	9*	9
Buffalo bulls	2	1
Cow calves and youngstock females	115	124
Cow calves and youngstock males	51	74
Buffalo youngstock females	9	9
Buffalo youngstock males	5	5
Bullocks	29	28
Horse	1	1
Sheep—		
Ewes	66	76
Rams	4	7
Female lambs	52	58
Male lambs	5	5
Total	492	552

*Includes 1 Stud bull on loan from Delhi.

No animals were purchased during the year.

	Male	Female	Total
Births—			
Tharparkar	37	36	73
Hariana	31	29	60
Buffalo calves	3	3	6
	T. P.	Har :	Total
Transfers from youngstock to adults—			
Cow Females	16	13	29
Cow Males	1	*Nil.*	1
	(Stud Bull)		
Buffalo females	2	..	2

Disposals—

(1) Cows	10	On account of old age, incurable disease or poor yields.
Cow female youngstock	3	Not conforming to type and colour or in other respects below standard.
Cow male youngstock	11	
(2) Buffalo bull	1	Sold to a private institution.
Buffalo youngstock males	3	Sold to Agricultural Department U. P. for breeding purposes.
(3) Buffaloes	8	Transferred to Bangalore Farm.
(4) Cow female calves	17	Disposed of at birth or at an early age for the following reasons :— (*a*) Low record of dam. (*b*) Not conforming to type. (*c*) Colour defects. (*d*) Under weight at birth. (*e*) Physical deformations.
Cow male calves	27	
Buffalo female calf	1	

Rejection of young calves has been carried out during the year on the above lines, to avoid condemnation at a later age, thus minimising the expenditure in upkeep. A few calves of light red colour of both sexes from good yielding dams were retained for purposes of observation as to the possibility of subsequent changes in colour.

Mating of adult stock was regulated from 2nd heat to 3 months after calving, keeping in view, age, milk yield, and the general health of animals. Heifers were not put to bulls until the age of 2½ years and young bulls brought into service at 3½ years of age.

Feeding of stock was done according to the scale of feed sanctioned by the Imperial Dairy Expert.

Comparative over-all averages of different breeds for three years :—

Year	Tharparkar	Variation Per cent.	Hariana	Variation Per cent.	Buffaloes	Variation Per cent.
1932-33	9·3	..	8·4	..	13·0	..
1933-34	9·4	+1·0	8·6	+2·0	11·8	—9·0
1934-35	9·8	+4·0	9·0	+4·4	10·1	—14·4

The drop in buffaloes yields is accounted for by (1) transfer of the best animals to Bangalore. (2) advanced age of present stock (3) new heifers have yet to complete their lactations.

Records of six of the best animals of each breed which completed their lactation during the year are given below :—

Serial No.	Animal No.	Age Yr.	M.	Milk Yield lb.	Days in milk	Remarks
				THARPARKAR		
(1)	119	15	0	7,249	391	Purchased 1925
(2)	262	9	7	6,059	412	Farm bred
(3)	266	10	0	6,117	357	Purchased
(4)	323	8	8	5,387	308	Farm bred
(5)	378	6	9	6,597	334	,, ,,
(6)	387	7	10	5,720	297	,, ,,
				HARIANA		
(1)	186	11	5	6,985	307	Purchased 1926
(2)	302	8	11	6,864	366	Farm bred
(3)	348	8	4	6,634	316	,, ,,
(4)	383	8	2	5,713	315	,, ,,
(5)	414	7	2	5,580	447	,, ,,
(6)	419	6	11	6,535	419	,, ,,
				BUFFALOES		
(1)	19	13	0	6,503	308	Purchased 1926
(2)	21	9	4	5,662	253	Farm bred
(3)	25	13	0	4,532	293	Purchased 1929
(4)	33	8	7	5,399	399	Farm bred
(5)	52	6	6	4,088	371	,, ,,

BREEDING

The main object is to fix a high milking standard, while conforming to breed, type and colour.

The results attained as compared with the purchased basic stock is shown by the following table which has been calculated from all

completed lactations (568 T. P. and 424 Har :) since 1923 :—

	Tharparkar		Hariana	
	Purchased	Farm bred	Purchased	Farm bred
Average milk yield lb.	2,294	3,791	2,379	3,634
" lactation period (days).	242	311	255	304
" dry days	147	95	150	106
" over-all (dry period included)	5·6	9·1	5·8	8·8

Average milk yield of animals which completed their lactations in 1934-35 :—

No. of animals	Average milk yield lb.	Average days in milk	Average days dry
Tharparkar . . . 66	3,441	265	102
Hariana . . . 57	3,538	297	123
Buffaloes . . . 6	5,090	309	152

Rearing of calves

The system of weaning at birth was strictly followed except in special cases where a few farm-bred animals have failed to give milk up to the standard in their first or second lactations, although descending from high milking parents.

Results of such experiments in cows were as follows :—

Cow No.	Breed	Milk yield in lb. and days			Remarks
		Best weaned	Not weaned		
215	T. P.	3659 / 288 (4)	5588 / 306 (6)	4456 / 253 (7)	Top figures denote milk in lbs. and bottom figures No. of days. Numericals in brackets denote No. of lactations.
313	"	2796 / 218 (3)	3446 / 325 (4)	2043 / 184 (5)	
342	Har :	2629 / 249 (2)	4426 / 303 (3)	3417 / 265 (4)	
			3230 / 230 (5)		
373	Har :	3861 / 278 (1)	2733 / 197 (4)		
386	"	2430 / 182 (3)	2604 / 184 (4)		
413	"	2022 / 206 (2)	2572 / 255 (3)		

All weaned calves upto one month old get only mother's milk fed from the pail and afterwards pure milk is gradually substituted by separated milk in addition to a small portion of concentrates and fodder upto 6 months, thereafter separated milk upto one year in addition to concentrates and fodder.

Mortality.—

Cow calves	13	Pneumonia, Dysentery, Fits, Joint ill, Dip poisoning, Hoven.
Buffalo calf	1	Pneumonia.

Following deaths occurred during the year :—

Diseases.—

Cows	2	1 old age and 1 destroyed for incurable disease.
Cow bull	1	(Snake Bite.)
Cow youngstock male	2	(H. S. and Pericarditis.)
Bullocks	2	(1 poisoned while grazing, 1 destroyed incurable sprain in lumber regions.)

The only outbreak of contagious disease in the herd was 2 cases of surra in calving stock and by timely treatment they recovered. After an examination by the Veterinary Investigation Officer, Punjab, one more cow in the herd was traced as being a carrier of surra and an injection was given under his instructions.

Preventive inoculations for rinderpest were carried out by the staff of the Imperial Institute of Veterinary Research, Muktesar in March.

The following 76 animals were treated :—

	S. S. Method	Virus alone
Cows	5	..
Buffaloes	1	..
Cow bull	1	..
Bullocks	9	..
Cow male youngstock	3	25
Cow female youngstock	..	31
Buffalo male youngstock	..	1
	19	57

Sheep.—Comparative average production of wool in sheep per head for last 3 years, which now consists of farm-bred stock only was as follows :—

Year	Average production lb.	oz.
1932-33	4	7
1933-34	5	1
1934-35	5	9

Deaths during the year.—9 (gid, grazing poisoning and other causes).

Experiments, Research and Demonstration

Milk tests to determine the quantities of butter fat and total solids in milk were conducted for the combined herds of cows and

buffaloes on the farm and also for individual animals of all breeds under the following heads :—

(1) Combined herd tests for each breed of cows and buffaloes, daily morning and evening.

(2) First calves of all the breed for one complete lactation daily morning and evening and also for these animals which have not been tested before for one full lactation.

(3) Weekly composite tests for the animals which completed one full lactation under daily tests.

(4) Alternative day tests which were started last year, were stopped in favour of above.

Number of animals under testing during the year

Description of test	Tharparkar		Hariana		Buffaloes	
	1st April 1934	31st March 1935	1st April 1934	31st March 1935	1st April 1934	31st March 1935
Daily .	18	13	15	12	1	4
Weekly .	16	36	14	27	..	3
Total .	34	49	29	39	1	7

Total on 1st April 1934 64
Total on 31st March 1935 95

Determination of outturn percentages of different by-products of milk such as cream, butter and *ghee* which commenced in the previous year was continued throughout the year.

Attached statement No. 1 gives some idea of the variations of butter fat, specific gravity and total solids in milk during the different seasons. Highest percentage of fat was produced by cows in the first quarter of the year (April to June).

Statement No. 2 shows the feed cost per animal per year and the quantity of fat produced against it.

3 Post-graduate students were here for two months and they were shown the following operations :—

(1) Homogenization and sterilization of milk.

(2) Butter making.

(3) *Ghee* making by modern (Steam Jacket) and country method.

(4) Casein making by—

(*a*) Rennet coagulation

(*b*) Acid coagulation

(*c*) Natural curdling

The Farm was visited by the following, who were shown around :—

Students from the Agricultural College, Lyallpur.

B. Sc., Agricultural Class of the Khalsa College, Amritsar.

A demonstration of the dairy section was arranged at the local Health and Baby Week.

No. 1.—Particulars of combined herd testing during the year 1934-35

Month	Average No. of cows daily.	Tharparkar Herd					
		Average B. F. test per cent.		Average Specific gravity		Average Total Solids per cent.	
		M.	E.	M.	E.	M.	E.
April 1934	43	4·6	5·2	31·1	30·1	13·54	14·05
May	43	4·6	5·1	30·4	29·6	13·34	13·75
June	41	4·7	5·0	30·0	29·5	13·42	13·56
July	41	4·5	4·6	31·2	30·4	13·41	13·31
August	42	4·5	4·5	32·4	31·4	13·79	13·51
September	45	4·4	4·4	32·8	31·7	13·49	13·40
October	40	4·4	4·8	32·0	30·0	13·50	13·41
November	45	4·4	4·9	31·3	30·0	13·36	13·69
December	51	4·3	4·9	33·2	31·7	13·82	14·03
January 1935	52	4·3	4·8	33·1	31·5	13·66	13·96
February	50	4·2	4·9	33·1	31·7	13·56	14·10
March	51	4·3	4·7	33·1	31·8	13·60	13·82
		Hariana Herd.					
April 1934	37	4·6	5·3	31·5	30·2	13·61	14·20
May	39	4·4	5·1	30·8	30·0	13·23	13·77
June	38	4·5	4·8	30·6	29·8	13·22	13·51
July	39	4·3	4·5	31·5	30·8	13·34	13·24
August	40	4·5	4·5	32·6	31·9	13·88	13·59
September	40	4·5	4·5	33·0	32·0	13·90	13·63
October	41	4·4	4·7	31·9	30·4	13·54	13·54
November	40	4·4	4·9	31·4	30·1	13·38	13·73
December	41	4·3	4·9	33·2	31·6	13·68	14·08
January 1935	41	4·2	4·8	33·2	31·7	13·61	13·97
February	41	4·3	4·8	33·1	31·7	13·71	13·98
March	42	4·2	4·6	33·5	32·3	13·70	13·91

Statement No. 2

Daily average of milking stock fed during the year (2 breeds of cows)	Daily average cost of feed (for column 1)	Average cost of feed per animal for the year	Number of animals completed lactation under weekly composite tests	Total amount of fat produced by animals (column 4)	Average quantity of fat produced per animal (column 4)
			T. P. Har:	T. P. Har:	T. P. Har:
				lbs. lbs.	lbs. lbs.
1	2	3	4	5	6
	Rs.	Rs.			
135	32 8 0	88	37 33	4,759 4,970	128·6 150·6

N.B.—To arrive at the average cost of feed per animal per year (Column 3), the averages have been taken for all the milking stock including dry and calving stock animals (Columns 1 and 2), and to arrive at the average quantity of fat produced per animal (column 6), the animals under column 4 have been taken into consideration.

REPORT OF THE PHYSIOLOGICAL CHEMIST

(A. Viswanatha Iyer, B.A.)

I.—CHARGE

Dr. Warth was in charge of the Section up till the 15th March 1935, when Mr. A. Viswanatha Iyer, Assistant Physiological Chemist, took over charge.

II.—RESEARCH

1. Experiments on milk production

High and normal protein feeding. This is a repetition of last year's experiment to corroborate the results of last year. The animals had for their feed, groundnut cake, cotton seed meal, brewery grain, crushed gram and wheat bran for concentrates and *ragi* straw, *Jowar* silage and guinea grass for roughages, the higher protein being adjusted by an increase of the cakes with a corresponding reduction of the other concentrates. The following tables I and II show the daily average food consumption and the milk yield per head for each group. Figures are given for four weekly periods of lactation.

TABLE I—*Food consumption, milk yield and live weight of cows in high and normal protein*

Periods in weeks	Dry Matter Average			Daily milk yield (Lbs.)	Fat per cent			Live weight	Dry Matter Average			Daily milk yield (Lbs.)	Fat per cent.			Live weight
	Rough. (Kg).	Concen. (Kg).	Total (Kg).		Morning	Evening	Average		Rough. (Kg).	Concen. (Kg).	Total (Kg).		Morning	Evening	Average	
			A Group	in Normal	Protein.						B Group	in High	Protein.			
1—4 . .	5·657	6·079	11·736	28·6	3·6	4·3	4·0	822	6·145	6·015	12·160	27·6	3·6	4·5	4·1	840
4—8 . .	5·701	5·653	11·354	26·6	3·7	4·4	4·1	831	6·186	5·889	12·075	26·5	3·8	4·5	4·2	851
8—12 . .	5·760	5·437	11·197	24·2	3·7	4·5	4·1	848	6·187	5·215	11·402	22·8	4·1	4·8	4·5	863
12—16 . .	5·713	5·041	10·754	21·7	3·8	4·6	4·2	851	6·142	4·814	10·956	20·7	4·0	4·7	4·4	870
16—20 . .	5·700	4·341	10·041	18·8	3·8	4·7	4·3	848	6·105	4·357	10·472	18·5	4·1	4·7	4·4	872
20—24 .	5·676	3·829	9·505	15·9	3·8	4·5	4·2	850	6·221	3·877	10·098	16·2	4·6	4·9	4·8	884
24—28	5·577	3·360	8·937	12·8	4·0	4·6	4·3	861	6·222	3·498	9·720	13·1	4·6	5·2	4·9	898

N.B.—Kilogramme into 2·2 will give weight in pounds.

TABLE II—*Food consumption by cows on high and normal protein ration (On thousand pound basis)*

Periods in weeks	A group. Normal protein.			B group. High protein.		
	Dry matter average		Total	Dry matter average		Total
	Roughage (Kg).	Concentrates (Kg).	(Kg).	Roughage (Kg).	Concentrates (Kg).	(Kg).
1—4 . . .	6·862	7·395	14·277	7·316	7·161	14·477
4—8 . . .	6·860	6·803	13·663	7·269	6·920	14·189
8—12 . . .	6·792	6·412	13·204	7·169	6·043	13·212
12—16 . . .	6·713	5·924	12·637	7·060	5·533	12·593
16—20 . . .	6·722	5·119	11·841	7·001	5·008	12·009
20—24 . . .	6·678	4·505	11·183	7·037	4·386	11·423
24—28 . . .	6·477	3·902	10·379	6·929	3·895	10·824
Average . .	6·732	5·723	12·455	7·112	5·564	12·676

The points to be noted are :—

(1) From Table II it will be observed that the food consumption of the B group is slightly higher than that of the A group. The B group animals ate more roughage than the A group, which is reflected in the increased live weight, which on the thousand pound basis is as 1069 : 1047.

The feeds contained 5·723 Kg. and 6·203 Kg. starch equivalents having 1·175 Kg. and 1·118 Kg. of digestible protein for groups A and B respectively. These are the average figures for the whole period.

(2) The milk yield for both the groups is more or less identical, but group B has yielded richer milk, the average fat content being 4·5 and 4·2 for groups B and A. The higher fat content for group B, may be due to the higher quantity of fat ingested through the feed and not the higher protein because of the proportionately larger quantity of cake fed.

2. EXPERIMENTS WITH PHOSPHATE SUPPLEMENT

An experiment for finding out the highest phosphoric acid level that a grown up animal is capable of retaining was in progress during the year.

Plan of experiment.—Three animals were selected and they had (1) *Ragi* straw, (2) Green guinea grass and (3) Groundnut cake for their feed. Calcium phosphate, Sodium phosphate and Ammonium phosphate were given as supplements, each being taken up one after the other in the order mentioned. Phosphate supplement was given in two levels, the first having 30 gms. per day followed immediately by 60 gms. during the second stage. The period

of feeding for each of these levels was in no case less than four weeks. After the 60 gms. supplement feeding there would be a period of no phosphate for 5 to 6 weeks, before another phosphate supplement is started. Faeces and urine were collected and analysed practically throughout the whole period. Mineral balance data were obtained for the entire period. In these experiments at every stage, acid base balance of the urine was determined as also the lime and phosphoric acid of the blood.

Before the phosphate supplement the animals were showing a negative lime balance, while phosphoric acid showed a small positive balance. As soon as the supplement was given both lime and phosphoric acid became positive, but could not retain that level, when the supplement was withdrawn. This remark applies only to the figures, when Calcium phosphate supplement was given. The other analyses are not completed and so are not capable of further elucidation.

From the ordinary analyses during the above period, the digestion figures do not call for any special remarks, as there is practically no difference in the figures with and without supplement.

These experiments will be reported in detail and form the subject matter of a publication as soon as the analyses are all completed.

3. Feeding experiment with Sulphate supplement

Two animals were selected and fed with Bolarum hay, green guinea grass and groundnut cake with 10 gms. of Calcium phosphate during the whole period of the experiment, the phosphate being added because the roughage is known to be poor in phosphoric acid. Preliminary digestion experiments were conducted and the mineral balance determined. Blood samples were also taken at different periods and Lime, Phosphoric acid, Sulphate and protein determined. Calcium sulphate was given as the supplement, 18 gms. being given per day. Determinations on the above lines were also conducted during this period. Since all the figures have not been collected, no general discussion is possible at the present stage. However, one tentative observation can be made, *viz.*, that the blood Ca has definitely increased and the inorganic P slightly decreased when the supplement was given.

4. Phosphate feeding Experiment with Growing Animals

Plan of experiment—Eight bull calves were selected and divided into two groups, one group getting Calcium phosphate as a supplement in addition to other rations. The ration consisted of Bolarum hay, green guinea grass, wheat bran and groundnut cake. The average daily consumption and the live weight are set out below.

TABLE III—(*Group*) *Average daily consumption of roughages and concentrates by calves*

No. of Weeks.	No Mineral group, actuals in Kgs.			Mineral group, actuals in Kgs.			No Mineral group, on 1,000 lbs. basis.			Live weight.	Mineral group on 1,000 lbs. basis.			Live weight.
	Rough.	Concen.	Total.	Rough.	Concen.	Total.	Rough.	Concen.	Total.		Rough.	Concen.	Total.	
1 . .	2·99	1·07	4·06	2·77	1·06	3·83	9·08	3·35	12·43	1,000	8·86	3·39	12·25	1,000
2 . .	3·27	1·07	4·34	3·06	1·06	4·12	10·11	3·31	13·42	1,013	9·66	3·35	13·01	1,018
3 . .	3·26	1·06	4·32	3·12	1·05	4·17	9·72	3·16	12·88	1,050	9·58	3·15	12·73	1,042
4 . .	3·29	1·09	4·38	3·13	1·08	4·21	9·71	3·22	12·93	1,061	9·50	3·28	12·78	1,053
5 . .	3·42	1·10	4·52	3·36	1·08	4·44	9·97	3·21	13·18	1,076	10·15	3·26	13·41	1,058
6 .	3·44	1·12	4·56	3·40	1·09	4·49	12·37	3·20	15·57	1,095	10·07	3·23	13·30	1,080
7 . .	3·54	1·13	4·67	3·44	1·12	4·56	12·47	3·16	15·63	1,119	10·03	3·27	13·30	1,097
8 . .	3·54	1·13	4·67	3·30	1·11	4·41	9·81	3·13	12·94	1,129	9·55	3·21	12·76	1,106
9 . .	3·27	1·12	4·39	3·27	1·12	4·39	8·93	3·06	11·99	1,145	9·30	3·19	12·49	1,129
10 . .	3·49	1·13	4·62	3·49	1·13	4·62	9·34	3·04	12·38	1,163	9·75	3·16	12·92	1,143

From the figures it will be noticed that the total consumption of the feed is slightly better with the 'No Mineral Group', and the live weight is also better. The experiment is continuing and detailed observations will be made as soon as it is finished.

5. Physiological Study of Blood

In the year under report, a small beginning has been made on the study of (1) Helmenthosis as affected by nutritional changes and (2) Physiological changes in blood under different feeds. Much progress could not be made for want of proper facilities and expert advice. From the little that has been done, it is observed that under similar conditions of feeding, some animals were poor in condition and were suspected to be cases due to intestinal parasites. On the regular examination of the fæces of these animals, 3 sheep and one bullock voided ova in the fæces.

Blood counts for all the experimental animals were systematically done and in some cases differential counts were also attempted. One important observation was that, Indian cattle gave always a higher count than that recorded for European or American cattle. The recorded figure for foreign animals is only 6 million per c.c. which for Indian animals examined, gave as much as 9 millions per c.c. In the case of cross bred animals of the farm the count agrees with the figure for foreign animals.

When the animals were receiving a phosphate supplement, the counts increased and as soon as the supplement was withdrawn it decreased. Of the two animals reported, Ismail and Basappa, the former did not show as large an increase as its fellow, Basappa. The fæces of this animal, when examined, contained ova. The animals, when getting Ammonium phosphate as supplement showed the general increase in count, but the cells were irregular in shape. The following table shows these in detail :—

Red Blood Cell Count variations in Bullocks with Phosphate

Basappa Counts in millions	Ismail Counts in millions	Remarks
6,640	5,500	Normal with no Phosphate.
8,028	5,576	With 30 gms. of Sod. phos.
9,168	6,520	With 60 gms. Sod. phos.
8,593	6,270	With no Phosphate.
..	6,096	With no Phosphate.
9,320	7,440	With 30 gms. Amm. Phos.
9,456	6,512	With 60 gms. Amm. Phos.
8,416	7,720	With no Phosphate.
8,336	..	With no Phosphate.

Note.—Blood cells were counted over Burker Hawksley chamber and ordinary Haemocytometer was used. Each figure represents the average of two or more counts from 100 small squares. [The animals had Ragi straw, Groundnut cake and green guinea grass for their feed]

The work is proceeding and it would take much longer study to draw any definite and general conclusions.

6. Digestion of Fats

Further work in connection with the common alkali hydrolysis method due to Liebermann has revealed the fact that in the presence of carbohydrates this method is not a reliable one, as there is a formation of fatty acids from this constituent due to the action of the alkali.

Experiments on ether extraction for the determination of fat have yielded the following facts. The available methods for the determination of fats in fodder and fæces by extraction do not yield quantitative results. Appreciable quantities of substances are left over which should form part of a study of fat metabolism. Repeated extractions up to about 400 hours with ethyl ether have shown that it is almost impossible to completely recover such fractions. The extract with petroleum ether is as much a mixture of non-fats as that obtained with ethyl ether. The resistant fractions have also been found to contain fatty acids in significant proportions.

A useful study of the nature and extent of the digestion of fats and fatty bodies involves this essential work of evolving a really quantitative method for their determination, especially with the chances that what is resistant to ether need not be so to the chemical and enzymic action of the digestive juices in the system. A detailed study is therefore in progress of the resistant fractions with a view to getting at a method for the quantitative determination of total lipoids in fodder, fæces, etc. The above observations are set out in detail in a paper which is submitted for publication.

All the same it was thought desirable to follow the changes in the nature of specific lipoid constituents such as the sterols, phospholipins, etc., during the process of digestion. An attempt has latterly been made to isolate the sterols in fodder and fæces and make a qualitative study of these. Work has not proceeded far enough to draw any conclusions.

7. Experiments with Sheep

The Sulphur metabolism studies were continued during the year. A new method for the determination of total sulphur in animal and vegetable material was worked out. Briefly the process consists of Nitric acid oxidation of the material followed by alkali fusion. Unless absolutely complete oxidation of organic matter takes place Nitric acid alone failed to convert all the Sulphur to sulphate. By fusing the product of Nitric acid oxidation it was found possible to reduce the time of oxidation enormously. Fusion also enables much larger quantities of material to be tackled, besides completing the oxidation of the Sulphur thus increasing the accuracy of the

determination especially of Sulphur poor material like straw. The following table gives yields of Barium sulphate from identical quantities of the same material with and without fusion. The results indicate the importance of fusion.

Effect of fusion on the yield of Sulphur in different substances

Substances	Yield of Barium Sulphate in mgms.	
	Without Fusion	After Fusion
Hay	61·5	65·0
Guinea grass	75·5	87·5
Groundnut cake	101·5	104·0
Urine	115·5	119·0
Fæces	86·5	92·0
Wool	93·0	95·5

A long period feeding test was carried out with sheep to study their wool production and Sulphur balance and several digestion experiments were also done. During the course of nearly 18 months the animals consumed daily on an average per 100 lbs. live weight, 1,206 gms. of dry matter containing 78·4 gms. of crude protein and yielding 0·85 lbs. of starch equivalent. They digested on an average 52·7 per cent. of the organic matter and 57·2 per cent. of the crude protein of their ration.

It was found that the live weights fluctuated somewhat roughly in accordance with food consumption and that the individual animals differed considerably in their efficiency for utilisation of food. Digestion experiments indicated that the food varied somewhat in quality and that consumption increased when the quality improved. The extent of such increased consumption was considerable.

Although the wool yields of these sheep are insignificant the important observation was made that yields fluctuated according to the nutritional state of the animals. The following table makes this point clear.

TABLE 4

Wool production in relation to live weight excess over initial live weight

Sheep Nos.	1		2		3		4		5		6		7		8	
	*L. W. Ex.	Wool gms.	L. W. Ex.	Wool gms.	L. W. Ex.	Wool gms.	L. W. Ex.	Wool gms.	L. W. Ex.	Wool gms.	L. W. Ex.	Wool gms.	L. W. Ex.	Wool gms.	L. W. Ex.	Wool gms.
First period . .	6	338	6	289	—2	258	..	..	7	249	8	280	7	404	..	..
Second period . .	3	280	3	235	—2	250	—3	375	6	235	8	290	11	445	—1	345
Third period . .	7	350	6	320	0	314	—2	460	7	320	10	350	12	520	0	355

* Live weight excess pounds.

It was also noticed that shearing of sheep during cold weather caused a serious loss of weight and consequently the animals suffered in their productivity also. The following table illustrates this point. The first shearing was done in the cold weather (January) and the second in hot weather (July).

Shearing Effect

Sheep Nos.	1	2	3	5	6	7
First period						
Initial weight . . . lbs.	67	52	47	63	55	47
Final weight . . . . ,,	73	58	45	70	63	54
Gain . . . . ,,	6	6	—2	7	8	7
Shearing effect	—5	—5	—3	—4	—3	—3
Second period						
Initial weight . . . lbs.	68	54	42	66	60	51
Final weight . . . . ,,	70	55	45	69	63	58
Gain . . . . ,,	2	1	3	3	3	7
Shearing effect	0	—1	—1	—2	—2	—2

The same set of sheep were employed simultaneously for the study of the effect of a supplement of Sodium sulphate. It was found that in the process of alimentation there is always a loss of total Sulphur and sulphate. When the sulphate content of the ration is low the loss of total Sulphur is very small. It was possible in such cases to account for almost all the ingested Sulphur. On the other hand when the amount of sulphate in the ration is considerable a large real loss of Sulphur occurs, indicating that volatile Sulphur compounds (H_2S, etc ,) are formed. The following tables indicate this.

Loss of Total Sulphur

—	Intake	Balance (loss)	Accounted for in wool and live weight increase	Unaccounted (loss)
With supplement . .	1·386	0·179	0·070	0·109
Without supplement .	0·309	0·085	0·078	0·007

Gain of Organic Sulphur

Sulphate Balance. Gain of Organic Sulphur contained in :—

	Sulphate Balance		Gain of Organic Sulphur contained in :—			Unaccounted (Loss)
	Intake	Balance (loss)	Urine and Fæces	Wool and Live weight increase	Total	
With supplement	0·916	0·221	0·042	0·070	0·112	0·109
Without supplement	0·337	0·064	—0·023	0·078	0·055	0·009

In contrast to the losses of total Sulphur and sulphate Sulphur it was found that a gain of organic Sulphur occurs. This organic Sulphur is formed from sulphate and the amount produced increased with the amount of sulphate ingested. That this increment of organic Sulphur plays a part in metabolism of the animal is indicated by the fact that the organic Sulphur content of the urine is increased by ingestion of inorganic sulphate. These results have been submitted for publication in a series of papers.

8. Sulphur in Grasses

The Sulphur distribution in grasses has been under enquiry during the year. It has been noticed that the water soluble non-protein organic Sulphur of some grasses fail to give the nitroprusside test besides incurring no loss whatsoever even after repeated treatments with Hydrochloric acid. There is, therefore, reason to believe that the Sulphur in these compounds is at least partially oxidised.

Regarding the sulphate content of grasses the important observation has been made that the tribe of the grass has decided characteristics in having high or low sulphate content. It has been noticed that the Chloridae contain the maximum amount of sulphate, while the Andropogonae, the Paniceae, etc., contain much less. The following figures collected from the analysis of grasses growing together in plots only a few square feet in area will make the point clear.

Sulphate content of Grasses

(Sulphate expressed as gms. Sulphur per cent)

Name of Grasses	Plot 1	Plot 2	Plot 3
Andropogon annulatus	..	..	0·055
Andropogon contortus	0·069	..	0·044
Andropogon pertusus	0·045	..	..
Chloris barbata	0·290	0·218	0·180
Cymbopogon	..	..	0·058
Digitaria sanguinalius	0·052	..	..
Elusine	0·185	..	..
Eragrostis	0·047	..	0·052
Panicum javanicum	..	0·069	0·061
Panicum maximum	0·038	0·068	..

9. Mineral Metabolism Experiments

Influence of progressive ripening of some fodders on the mineral nutrition of cattle was studied and reported. The fodders examined were :—

1. Rhodes grass . . . . . 2 cuts
2. Aurangabad hay . . . . . 3 cuts
3. Spear grass hay . . . . . 2 cuts
4. Jowar hay . . . . . 3 cuts

The mineral content was found to vary from fodder to fodder and with the state of maturity. It was found that the state of maturity greatly affected the mineral assimilation. From the data obtained it was found that to produce a positive balance with Lime and Phosphoric acid under minimum maintenance conditions the amount present in the feed should not be less than 15 gms. CaO, 10 gms. P_2O_5 for an animal of 750 lbs. live weight, when other conditions are favourable. It appears that with less Lime and Phosphoric acid than these amounts, no positive balance is possible under any circumstances. Another interesting point is that while a positive Lime balance can be obtained, when the Lime is above the minimum, but the Phosphoric acid below, the converse *viz.*, a positive Phosphoric acid balance, when Lime is below the minimum seems unattainable.

10. Acid Base Equilibrium

The study of the influence of progressive ripening of fodders on the acid base balance of urine was continued during the year. Four typical fodders at different stages of maturity were fed to

cattle and the resulting urines studied. Some important results were obtained. The data are presented in the following table :—

Urinary excretion of acids and bases in c.c. N per 1000 gms. Fodder.

——	Total fixed bases	Total acids	Excess of base	CO_2	Ammonia	pH of urine	Volume of urine in litres per day
1. Rhodes grass hay (Bangalore)—							
1st cut .	818·7	507·2	311·5	488·8	7·6	7·98	10·105
2nd cut .	518·3	506·5	11·8	40·9	5·8	7·40	5·891
2. Aurangabad hay—							
1st cut .	264·5	249·1	15·4	36·8	6·7	6·62	3·074
2nd cut .	202·1	190·0	12·1	18·5	3·4	6·25	1·912
3rd cut .	138·5	158·0	—19·5	1·5	10·8	5·72	1·361
3. Spear grass hay (Bangalore)—							
1st cut .	296·7	296·6	0·1	40·5	7·9	7·22	5·820
2nd cut .	137·5	189·2	—51·7	1·8	63·7	5·85	2·074
4. Jowar hay—							
1st cut .	655·4	414·5	240·9	274·6	5·4	7·90	5·964
2nd cut .	411·4	328·3	83·1	115·8	5·5	7·60	4·131
3rd cut .	330·1	290·0	40·1	41·9	3·3	7·40	3·548

It may be noticed that the early cut fodders are marked by the production of large volumes of urine which may be definitely attributed to the high amount of alkalis present therein. With later cuts the volumes decrease. There is also the decrease in the excretion of fixed bases in the urine as the stage of maturity of the crop advances and consequently the pH of the urine tends to become lower and for the same reason the carbon dioxide content of the urine also diminishes. Some of the later cut fodders are distinctly acidic. In the case of Aurangabad hay and Spear grass hay the bases excreted are low even in the early cut samples and later cuts show serious deficiency of bases. Spear grass hay may be said to produce nutritional acidosis, marked by a large increase of urinary Ammonia.

Another point which may be noticed is that although fodders 1 and 3 were grown on similar soil, yet the one has produced an alkaline urine and the other an acid urine. The species of grass and the stage of maturity both profoundly influence the mineral supply to and the acid base balance in the animal.

Another observation that was made is the increased deflection of lime and magnesia into the acidic urine, the excretion being not proportional to the intake but depending almost entirely on the pH of the urine. This suggests, therefore, that the animal experiences difficulty in retaining minerals when the urine becomes acid. Mineral balance experiments done go to confirm this view.

All these are more fully dealt with in a paper which has been submitted for publication in the Indian Journal of Veterinary Science and Animal Husbandry.

An important study of the effect of feeding different phosphates to cattle fed with a basal ration on the gradual change in the nature of the urine and in the acid base balance of urine has been undertaken and would be fully dealt with later on.

11. Calcium and phosphorous content of blood serum

The Ca and P content of the blood serum of the animals with three of the four fodders at different stages of maturity is given in Table V below.

Table V

Effect of Ca/P ratio of Fodder on Serum Ca and inorganic P.

	Ca intake per day gm.	P intake per day gm.	Ca/P ratio. per cent.	P in serum Mgm. per cent.	Ca in serum Mgm. per cent.	Acid base balance in urine c.c. N. alkali per day.
Aurangabad hay—						
1st cut	20·19	5·35	3·78	5·08	10·84	67 2
2nd cut	17·56	4·00	4·38	5 11	11·76	53·2
3rd cut	19·92	3·00	6·63	4·94	13·18	—94·4
Spear grass hay—						
1st cut	18·42	7·93	2·32	5·99	11 38	—0 9
2nd cut	19·29	4·81	4·01	5·48	13·17	—243·0
Jowar hay—						
1st cut	13·05	10·53	1·24	6·08	11·15	1119·3
2nd cut	10·20	10·14	1·01	5·39	10·85	868·8
3rd cut	7·65	12·78	0 60	6·08	12·60	186·3

It will be seen that the blood serum P value does not vary according to intake alone, but is also dependent on the nature of the fodder. For example in the Spear grass hay test with an intake of 4·81 gr. P, the serum P level was found to be 5·48 m. g. and in the former test, with much higher intake of 10·14 gr.P, the serum P level was only 5·39 m. g.

Blood calcium varies with different fodders. It is not related to the Calcium content of the food, and there is no direct relationship between the Ca/P ratio and the serum Calcium, but the blood Calcium level is influenced by the nature of the food and the stage of maturity of the fodder.

Serum Calcium is frequently parallel to the acid base balance and the urinary excretion of Calcium; but there are important exceptions to these rules.

12. Minerals in Pasture Grasses

Mineral composition of three pure species, Andropogon contortus, Cynodon dactylon and Pennesetum cenchroides, grown

at Pusa, Sabour and Bangalore for two consecutive seasons was studied and submitted for publication. The following factors were noted :

Distinct differences in mineral content of the grasses are noticed due to the nature of the soil. For example, the grasses grown at Pusa invariably contain more Lime and less Phosphoric acid than the average, the soil itself containing as much as 18 per cent. CaO.

It was found that each species of the grass showed a tendency towards a mineral make up peculiar to itself, Cynodon dactylon invariably showed a considerable excess of lime over phosphoric acid, while in Pennesetum cenchroides, the tendency was for Phosphoric acid to exceed Lime. The latter is an unusual phenomenon and is observed only in two other species, *viz.*, Guinea Grass and Jowar, grown at Bangalore.

The maturing of grass was found to exert a considerable influence on the per cent. of Nitrogen and Potash in the grass, a smaller influence on the per cent. of P_2O_5 and only a minor effect on the per cent. of Lime and Magnesia.

III. PUBLICATIONS

The following papers were sent for publication during the year under report :—

1. The influence of Progressive Ripening of Fodders on the Mineral Nutrition of Cattle, Part I. Mineral Composition and the Mineral Balance as influenced by progressive ripening of Fodders, by A. Viswanatha Iyer, Assistant Physiological Chemist.
2. The Influence of Progressive Ripening of Fodders on the Mineral Nutrition of Cattle, Part II, Urine characteristic as influenced by progressive ripening of fodders, by N. Krishna Ayyar, Assistant to the Physiological Chemist.
3. The Influence of Progressive Ripening of Fodders on the Mineral Nutrition of Cattle, Part III, The Blood characteristics as influenced by progressive ripening of fodders, by N. C. Das Gupta, Assistant to the Physiological Chemist.
4. Minerals in Grasses in India, by A. Viswanatha Iyer, Asst. Physiological Chemist.
5. The Determination of Sulphur in Balance Experiments with Cattle and Sheep, by N. S. Krishnan, Animal Nutrition Section, Bangalore.
6. A New Bleeding Rack, by N. S. Sankaranarayanan, & T. Fieldman, Animal Nutrition Section, Bangalore.

7. On the Unsuitability of the Existing Methods for the Determination of Fats in Biological Materials, by P. A. Seshan, Animal Nutrition Section, Bangalore.
8. A Feeding Experiment with Sheep, by F. J. Warth & T. S. Krishnan, Animal Nutrition Section, Bangalore.
9. Sulphur and Sulphate Balance Experiment with Sheep, by F. J. Warth & T. S. Krishnan, Animal Nutrition Section, Bangalore.
10. Minerals in Pasture Grasses in India, by A. Viswanatha Iyer, Assistant Physiological Chemist. (Prepared for the use of The Imperial Bureau of Plant Genetics, Great Britain).

IV. PROGRAMME OF WORK FOR 1935-36

Major Subjects

1. Experiments in the Nutrition of growing Animals
2. Experiments on milk production, including mineral assimilation
3. A study of Indian coarse fodders
4. Indian pasture grasses; a survey of their mineral composition
5. Blood analysis
6. Sheep-feeding experiments
7. Physiological Studies

Minor Subjects

1. A study of the chemical methods employed in the above enquiries
2. Preliminary experiments for the initiation of work on other aspects of Nutrition

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