

REPORT  
OF  
THE BOSE INSTITUTE  
FOR  
1953—54

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| <i>Scheme</i>                                    | <i>Sponsoring Body</i>                            | <i>Amount sanctioned</i> |     |    |
|--------------------------------------------------|---------------------------------------------------|--------------------------|-----|----|
|                                                  |                                                   | Rs.                      | As. | P. |
| Breeding of long stapled cotton                  | Director of Agriculture<br>West Bengal            | 13,058                   | 0   | 6  |
| X-ray irradiation on jute seeds                  | Indian Central Jute Committee                     | 9,738                    | 0   | 0  |
| Treatment of jute fibre with<br>synthetic resins | Do.                                               | 11,704                   | 0   | 0  |
| X-ray irradiation on oilseeds                    | Indian Central Oilseeds<br>Committee              | 23,300                   | 0   | 0  |
| Weed control scheme                              | I. C. A. R.                                       | 4,007                    | 12  | 6  |
| Palaeobotanical research scheme                  | Burmah Oil Co.                                    | 4,000                    | 0   | 0  |
| Antibiotic production scheme                     | C. S. I. R.                                       | 6,792                    | 0   | 0  |
|                                                  | Sir J. C. Bose Trust No. 1                        | 5,000                    | 0   | 0  |
|                                                  |                                                   | 77,599                   | 13  | 0  |
| Cosmic ray investigation                         | Board of research on Atomic<br>Energy Commission. | 35,730                   | 6   | 0  |
| Nuclear physics investigation                    | Do.                                               | 15,489                   | 4   | 3  |
| Neutron generator investigation                  | Do.                                               | 15,029                   | 0   | 0  |
| Photosynthesis                                   | Do.                                               | 7,922                    | 8   | 3  |
|                                                  |                                                   | 74,171                   | 2   | 6  |

**Revenue account.** It was mentioned in last year's report that the accumulated deficit from 1950-51 came up to Rs. 35,952-11-7. This year's audited account reveals a surplus of Rs. 321-4-5 leaving a net deficit of Rs. 35,631-7-2.

On request, the Institute has forwarded to the Ministry of Natural Resources and Scientific Research five years' estimates from 1954-55 to 1958-59 of anticipated recurring expenditure. Provision has been made in these estimates for the creation of certain new posts. So far no intimation has been received from the Ministry concerned, of the acceptance of the estimates for 1954-55. Unless an enhanced grant is received it will not be possible to fill up the new posts whose creation has been approved by the Council already in 1952-53.

**Acharya Jagadish Chandra Bose Memorial Lecture.** The fifteenth lecture of the series entitled "Role of Sand and Silt in Economy of Multipurpose River Valley Projects" was delivered by Dr. N. K. Bose, M.Sc., Ph.D., F.N.I., on November 30, 1953. The lecture has been printed along with the Director's Report presented to the 36th Anniver-



# REPORT OF THE BOSE INSTITUTE

## 1953-54

**Governing Body.** Three meetings of the Governing Body were held during the year. Besides the usual passing of audited accounts and the sanctioning of budget estimates, the Governing Body framed rules for the award of the Mary and Richard Keatings Research Studentship. It also nominated the first recipient, who has been granted permission to join in August, 1954 to enable him to complete his period of research fellowship in the Purdue University, U.S.A.

**Council.** Two meetings of the Council were held during the year. Besides the usual routine activities the following important decisions were taken during the year. The Council (i) recommended the extension by one year of the period of service of the Director, Dr. D. M. Bose (ii) appointed on the recommendation of a Selection Committee, Dr. P. K. Bose, till lately Director, Lac Research Institute, Namkum, Ranchi as Head of the Department of Chemistry.

### GRANTS :

**a) Non-recurring :** The following non-recurring grants were received from the Government of India during the year.

Rs. 75,000/- to be allocated as follows :

|                   |              |
|-------------------|--------------|
| Apparatus         | Rs. 47,000/- |
| Library equipment | Rs. 20,000/- |
| Cold room         | Rs. 8,000/-  |

Though applications for the purpose were made, no special grants were received either from the Central Government or from the State Government of West Bengal for meeting the balance of the amount due for the purchase of the property at Shamnagar. This amount has been paid by means of a loan as well as by an overdraft.

**b) Recurring :** The following recurring grants were received during the year:

|                          |                                               |                |
|--------------------------|-----------------------------------------------|----------------|
| From Government of India | (a) Recurring grant                           | Rs. 1,60,000/- |
|                          | (b) Ad hoc grant                              | 20,000/-       |
|                          | (c) Grant for training in scientific research | 6,670/-        |

**Grants-in-aid:** The following grants-in-aid have been received during the year, including a new grant from C.S.I.R. for investigation



**Other lectures.** Lectures were delivered in the Institute by Dr. F. C. Bawden, F.R.S. of the Rothamsted Experimental Station, Harpenden Herts, England on "Plant Viruses"; Prof. G. F. Alexandrov (U.S.S.R.) on "Scientific Organisation in Soviet Russia"; Dr Arthur Compton of Washington University, St. Louis on "Recent Advances in Physics".

Sj. Nirmal Kumar Bose gave a series of three lectures on "Temple Architecture of India" which were illustrated with lantern slides.

**Visitors:** The following visited the Institute during 1953-54: Prof. G. I. Finch, F.R.S., Director, National Chemical Laboratory, Poona; Prof H. S. W. Massey, F.R.S., Goldsmith Professor of Mathematics, University College, London; Sri Keshava Deva Malaviya, Deputy Minister, Ministry of Natural Resources and Scientific Research, Government of India; Prof. F. J. M. Stratton, F.R.S., Cambridge University, Cambridge; Dr. E. B. Chain, F.R.S., Scientific Director, International Centre for Research in Chemical Microbiology; Dr. F. C. Bawden, Rothamsted Experimental Station, England; Prof. G. F. Alexandrov and party from U.S.S.R. and delegates to the Indian Science Congress; Dr. W. E. S. Turner, Sheffield University; Prof. Julian Huxley, F.R.S. visited Mayapuri Station, Darjeeling; Members of the C.S.I.R. Reviewing Committee including Sir Arthur Egerton, London, Prof. Gaston Dupony, Paris, Sri B. R. Batra, New Delhi, Prof. S. N. Bose, Calcutta and Dr. E. H. Bucknall, Jamshedpur; Dr. Arthur H. Compton and Mrs Compton, Washington and Dr. Everett Ross Clinchy and Mrs. Clinchy, New York of World Brotherhood and Mr. and Mrs. William A. Schimer of Honolulu, Hawaii; Lady Hartog; Sri Jagan Prasad Rawat, Deputy Minister, Uttar Pradesh; Sri Raj Bahadur; Deva Singh Chauhan, Education Minister Hyderabad; Narothan Lal Joshi, Speaker, Uttar Pradesh Assembly, Lucknow; A. S. Patwardhan, Speaker, Madhya Pradesh Assembly; Dattatanaya Kashinath Kunli, Speaker, Bombay Legislative Assembly; R.S. Hukerikav, Chairman, Legislative Council, Bombay; Sailo Kumar Mukherjee, Speaker, West Bengal Legislative Assembly; Afghan Cultural Delegation headed by Dr A. Ahmed Popal and others.

### STAFF CHANGES

**Obituary** :—Dr. Basudeb Banerji, Research Fellow in Chemistry, who was on leave since November 1951, died on 15th April 1953. Dr. Banerji served the Institute for more than 10 years, first as Sir J. C. Bose Research Fellow of the Calcutta University, and later as an Institute Fellow. He was deputed for special studies and research with Prof. Hesse and Prof. Kuhn in Germany, as Government of India Overseas Scholar. A memorial plaque in memory of Dr. Banerji was placed in the Chemical



Dr. J. K. Chowdhury, Head of the Department of Chemistry, retired from service from 16.1.54.

Dr. P. K. Bose, Director of the Indian Lac Research Institute, was appointed Head of the Department of Chemistry and he joined on 10.3.54.

Dr. D. P. Burma, Research Assistant in Chemistry, was appointed a Research Fellow, *vice* Dr. B. Banerji deceased, from 1.11.53.

Sri T. C. Bhadra, Research Scholar in Physics, was appointed a Research Assistant from 1.1.54, *vice* Dr. D. P. Burma promoted.

The following were appointed scholars during the year :

Sri Ajit Kumar Mishra was appointed a Government of India Junior Scholar in Microbiology from 2.2.54 *vice* Sri Samir Kar resigned.

Sri V. N. Gadgil, a Government of India Junior Scholar on deputation from the Nagpur University, was appointed a General Scholar from 2.11.53.

Dr. C. V. Ramakrishnan, Birla Scholar and Sri R. P. Chatterji Research Assistant in the scheme of investigation on impregnation of bleached jute yarns with suitable synthetic resins, resigned from 1.6.53 and 11.2.54 respectively. Dr. Ramakrishnan was awarded a post-doctorate fellowship of the National Research Council of Canada and Sri Chatterji got an appointment in the Cinchona Department of West Bengal Government at Mungpoo.

Sri Gurupada Sen, Government of India Junior Scholar was appointed a Senior Scientific Assistant and Sri S. B. Ghosh a Junior Scientific Assistant from 3.12.53, in the scheme on the production of antibiotic substances from *Streptomyces* spp., financed by the Council of Scientific and Industrial Research.

The following were appointed in the scheme on "Use of  $C^{14}$  and  $P^{32}$  as tracers in photosynthetic and plant genetic investigations" financed by the Board of Research on Atomic Energy :

Sri S. B. Datta, Radio Chemist from 1.5.53 (resigned from 1.3.54).

Sri S. B. Sarkar (General Scholar), Plant Physiologist from 1.8.53.

Sri Syamapada Sen, on study abroad, was awarded Mary and Richard Keatings Studentship.

**Regrouping of Departments.** The two storied building recently erected to the south west corner of the Institute quadrangle is in course of occupation. The workshop has been transferred to the ground floor. Sufficient storage accommodation has been provided in the workshop in which most of the accumulated stock of apparatus, previously stored



been fitted up as a stack room which now also serves at present as a reading room. The western room is being fitted up as Reading Room. Trial orders for chairs, tables, and journal stacks have been placed, from which selection will be made for the reading room furniture. Wall space is available in the western room for future extension of the library. The Institute has received a grant of Rs. 20,000/- from the Government of India for library equipment.

The old workshop of area 992 sq.ft. is being refitted as the administration block of the Institute which will accommodate the Registrar's and the Accounts offices.

A couple of ground floor rooms, opposite to the Director's office which were used previously as apparatus stack room, is being converted into (i) an air conditioned room of size 32'  $\times$  13'  $\times$  7' to be maintained at a temperature of 75° F; inside the latter a cold room of size 6'  $\times$  6'  $\times$  6' to be maintained at a temperature of about 0°C is being fitted up. The rest of the air conditioned room contains a working bench, a Tiseleus electrophoresis apparatus constructed in the Institute workshop. The cold temperature room will be used mainly for enzyme investigations. The upper floor of size 32'  $\times$  13'  $\times$  7' will house a refrigerating and other centrifuges, a recently purchased Warburg's apparatus and other apparatus for which orders have been placed. This laboratory will be used mainly for plant biochemical investigations. For the cold temperature rooms a Government of India grant of Rs. 8,000/- has been received.

**Mayapuri Research Station.** With the termination of the ICI Research Fellowship awarded to Dr. A. Ganguly and on his appointment as Mycologist at Pussa, the work in the Plant Pathological Laboratory has been temporarily suspended. Though the Government of West Bengal had given administrative sanction to a scheme for the continuation of the Plant Pathological Laboratory, funds were not provided for it in the current year's budget. It is necessary to point out that work of this applied nature, from which the State of West Bengal will benefit principally, cannot be carried out by the Institute without grants-in-aid.

Investigations on Cosmic rays have been re-started at Mayapuri from December 1953 under grant received from the Atomic Energy Commission. It is proposed to extend the number of investigations which will be carried out there.

**Agricultural Experiment Station.** The Institute has a station at Falta and a temporary station on rented land at Bamangachi. As reported last year a 40 bigha property with tanks and some buildings was purchased in April, 1953 at Shamnagar, next station to Barrackpur. The rented land at Bamangachi was given up end of July and the staff



The soil has been found very suitable for agricultural experiments. Due to shortage of funds, certain necessary improvements to the Experiment Station have been kept in abeyance. These include the provision of staff quarters, laboratory accommodation, increasing the water storage capacity of two existing tanks etc.

**Research activities.** In a subsequent section technical summaries are given of the programme of research undertaken in the different departments. Here a non-technical account is given of some of the noticeable results which have been obtained, or new research developments, which have been brought into operation during the year.

**Physics.** It has been felt for sometime that the Institute has not done anything substantial to extend the founder's pioneering physical and biophysical investigations. A beginning has been made during last year, to study J. C. Bose's Electric Wave apparatus in light of modern concepts of wave guide etc. Investigations have been taken up, to find out how J. C. Bose's apparatus can be modified for quantitative measurements, in the wave length region below one centimetre. For this purpose modification of both the radiator and of the detector may be necessary.

Since the days when J. C. Bose had introduced the study on the nature of action potentials in plants and their propagation, the technique employed for similar studies in animal physiology has been considerably improved by the introduction of valve tube amplification and fast recording by oscillographs. In Japan such technique has been adapted recently to the study of excitation phenomena in *Mimosa pudica*. Much remains yet to be investigated. Apparatus using valve tube amplification and fast recording arrangement, has been constructed in the Institute and will put in operation when a short period galvanometer (.016 sec) is obtained from abroad.

**Chemistry.** This department in collaboration with workers in the Plant Physiology department, is developing the technique of using radioactive tracers like  $C^{14}$  and  $P^{32}$  for following plant metabolic processes including photosynthesis. For this purpose paper chromatography and autoradiography techniques are being employed. With the completion of the cold room, of the electrophoresis apparatus and the equipment of the low temperature laboratory with apparatus like refrigerating and other types of centrifuges, Warburg's apparatus and other apparatus, which have been either purchased or being purchased out of the Government of India's apparatus grant of Rs. 47,000/- this laboratory will be equipped for the isolation of particulate bodies like virus, mitochondria, microsomes etc., and for the study of their biochemical behaviour, as well as of



**Plant Physiology.** The algae *Chlorella* and *Scenedesmus*, which have been used mainly for photosynthetic studies in the U.S.A. and other countries, have been collected and their photosynthetic activities under various environmental condition studied. The feasibility of using photosynthetic products of different kinds of algae as food substitute is being investigated in U.S.A. and Japan. For tropical countries a type of alga is required which can remain active at higher mean temperature of the tropical countries, and whose chlorophyll content is comparatively low so that they can fully utilize the absorbed sun light for photosynthesis.

**J. C. Bose's active substance.** Recent investigations with highly metabolising animal tissues like liver, kidney, heart, and skeletal muscles have established the occurrence in them of particulate bodies identified as mitochondria, whose density of occurrence is proportional to the activity of the organ. Staining investigations on thin sections of contractile plant pulvini have shown that in them mitochondria bodies also occur in proportion to their contractile activity, being the highest in the main pulvinus of *M. pudica* and lowest in the inactive pulvinus of *Phaseolus*. These bodies are not identical with J. C. Bose's active substance whose nature is still under investigation.

**Cytogenetics.** The Institute has been carrying out investigations on the production of mutants in economic plants by x-ray irradiation of seeds and by selecting out of the mutants those with desirable economic properties. By irradiation of Jute variety *Corchorus olitorius* var. R26, new strain named Tall Mutant with several desirable economic properties has been evolved, which has remained stable upto seven generations.

Irradiation experiments have been started since 1950 on *Sesamum* (Til) and *Brassica* (Mustard). In some irradiated Bengal Types of *Sesamum* e.g. No. 12 and No. 16 substantial increase in yield of fruits and in weight of seeds have been observed upto the third generation. The yield of oil, their chemical composition are being studied. Similar results of significant increase in yield are observed with some strains of *Brassica* (Mustard), but they are still in the early stage of selection.

This year a new mutagenic agent, the B-ray active  $P^{32}$ , in the form of sodium dihydrogen phosphate solution, has been used to soak the jute seeds. Phosphorus salts are selectively absorbed in the plant nuclei and the *in situ* B-irradiation from  $P^{32}$  is a very of effective mutagenic agent. Out of the plants raised from such treated seeds of R26, a few have shown the characteristics of the Tall Mutant, while some are entirely green having the character of another *Olitorius* var. *Chinsura Green*.

It is a curious fact that during the past nine years irradiation of R26



experiments are being repeated (i) with seeds obtained from the P<sup>32</sup> mutants and (ii) freshly treated seeds. The group (i) are showing the morphological characteristics of their parents and in (ii) amongst other results from a treated tall mutant a Chinsura Green plant has come out. It appears that red coloration probably arises from a single gene mutation which also affects other properties of the Jute plant. The relation between gene mutation and anthocyanin coloration have been previously studied in England and other countries in plants like primroses and sweet peas. A similar line of investigation will be started soon in collaboration with the Chemistry Department.

**Microbiology—Retting of Jute.** The good appearance of jute fibres grown in E. Pakistan is due principally to the unlimited supply of running water in which jute plants are retted. In West Bengal and in other states of the Indian Union where good quality of jute is grown, the retted fibre usually gets discoloured. This is due principally to the paucity of suitable running water for retting. Jute plants have to be retted in muddy pools. Besides, the long continued process of retting in stagnant water for periods of 2-3 weeks favours the growth of noxious bacteria which foul the pond water with the emission of sulphurous odours.

Since 1940 the problem of retting of jute and other bast fibres under controlled conditions has been engaging the attention of the Microbiological Department of the Institute. It was early noticed that certain type of fungus like *T. paradoxa*, isolated from rotting pineapple and grown on suitable substrates, provide a good retting agent. In the process evolved, the jute sticks were kept immersed in water in suitable metal containers, to which the retting agent was introduced. The result obtained though satisfactory in many ways, suffered from certain limitations. For big scale application *e.g.*, it involved a large amount of capital expenditure in the construction of artificial retting tanks. Moreover the tank water has to be frequently changed.

An ideal method of retting in provinces like West Bengal, is by stack retting. The jute plants are piled in stacks and kept moist by sprinkling of water; a required quantity of a suitable substrate on which a very powerful retting microorganism has been grown is then strewn on the surface of the stacked plants. As a result of new investigations carried out during the last three years, a very active strain of *A. niger* has been isolated, which has been found to ret jute fibres very quickly. The retting potency of this strain has been substantially increased by growing on certain suitable media like wheat bran. Jute sticks were found to be retted in three days in the laboratory. Pilot scale investigation on large stacks of one year old jute sticks have recently been undertaken. The sticks were completely retted in three days. One of the gratifying features



required, and no malodorous smells are given out. The economics of the method of retting and its feasibility under field conditions require to be worked out.

**Plant Pathology.** In the Mayapuri Research Station systematic attempts have been made during the last years to breed virus resistant potatoes by suitable hybridisation of commercial varieties of potatoes with different diploid South American wild species. This promising line of work has to be suspended, it is hoped temporarily, due to the inability of the State Government to provide grants for the continuation of the plant pathological work at Darjeeling. The ICI Research Fellow in charge of the laboratory whose term is due to expire in May this year, has taken up an appointment as Mycologist in Pussa. In June 1953 the attention of the Central Ministry of Agriculture was drawn to a note published by the Research Fellow in "Science and Culture", on the outbreak of a new type of fungal disease, not previously known in this country, potato Wart, among an imported variety of potato Furore grown in the Government Potato Seed Farm at Runghat. Since then prompt action has been taken by officers of the Central Agricultural Department to destroy the infected plants. It remains to be seen whether the disease has in the meantime spread to other plots in the farm.

**Zoology.** In the last year's report it was mentioned that by suitable antibiotic treatment, the larval state of the tadpoles of *Rana tigris* could be prolonged by more than one year in some cases. It has now been found that such retarded tadpoles can be transformed into froglets within a week of treatment with certain concentration of vitamin B<sub>12</sub>. As a working hypothesis it has been assumed, that the metamorphosis of tadpoles is due to the action of B<sub>12</sub> produced by some bacterial microflora, whose growth had been retarded by the action of antibiotics like penicillin. The bacterial intestinal flora of the tadpoles in the premetamorphic stage, both in the treated and control specimens, are being investigated to discover if any support can be obtained for this hypothesis.



## A. PHYSICS

### A. 1. New Apparatus.

The following apparatus have been constructed during the year :

(1) A standard dosimeter with which the intensity of x-ray beams used to irradiate plant seeds for inducing mutation, can be measured directly in "r" units.

(2) A balanced type of d.c. linear amplifier circuit for measurement of plant bioelectric potentials has been constructed. It will be used for continuing with modern instrumentations, J. C. Bose's pioneer studies on production of active potentials in plant organs under stimulation and their propagation.

(3) *J. C. Bose's Electric Wave apparatus*—So far no work has been undertaken in the Institute to follow up J. C. Bose's pioneer investigations with the centimeter wave length electromagnetic wave apparatus constructed by him in 1895. Recently an apparatus of a similar type has been placed in the market by Leybold and Co. employing a more powerful spark generator of continuous e.m. wave, from which a monochromatic beam of 5 cm. wave length is sorted out by transmission through two wave guide tubes of different diameter. The energy of emitted radiation is measured by means of a selenium detector and there is an arrangement for direct determination of the wave length of the radiation.

This apparatus has recently been obtained from Germany and a comparative study is being made of the arrangements used for producing e.m. radiation, its monochromatisation and its wave length measurement. The aim is to redesign J. C. Bose's apparatus for quantitative measurements in wave length region below 1 centimeter.

### A. 2. Ultrasonics

#### A. 2.1. *Measurement of the intensity of ultrasonic waves in liquid by Radiation pressure method*

In the previous year's report the maximum ultrasonic energy available from an x-cut quartz plate vibrating at a frequency of 1 mc/s was reported. Ultrasonic output power of the quartz plate was measured by a calorimetric substitution method. The results have been published in the *Indian Journal of Physics* (Vol. 27, Oct., 1953). In the present investigation, a method of surveying the distribution of the intensity of progressive ultrasonic waves in liquid medium is described. A conventional Hartley type oscillator is used to feed the crystal transducer



A special radiometer was used for measurement of intensity of the ultrasonic radiation. In this method the mean radiation pressure was assumed to be proportional to the energy density in the neighbourhood of the obstacles and on this basis relative measurements were made in the radiation field of an ultrasonic oscillator.

The ultrasonic radiation pressure was measured with a sensitive chemical balance, using a steel ball suspended from the bottom of a scale pan by means of a fine thread from one of its arm. Between the U.S. generator and the steel ball was placed a cellophane membrane in order to minimize the effect of direct current flow round the ball. Observations were made under two conditions (1) at constant energy density the radiation pressure was measured with balls of different diameters (2) by using one ball, radiation pressure was measured at different energy densities. Five balls having the radii 0.43 cm., 0.36 cm. 0.32 cm. and 0.24 cm. were used. The investigation is being continued.

A. 2.2 *Measurement of the relative intensity of light in different orders diffracted in a liquid medium traversed by ultrasonic energy*

The apparatus for measuring the intensity of light in different orders of the diffracted pattern formed by Debye-Sears technique is working smoothly. It consists of a vacuum photocell type RGA 919, followed by a D.C. amplifier and a galvanometer. For allowing light from only one of the lines of the diffracted pattern to be incident on the photocell, a double slit arrangement has been made. Measurements are being made at a frequency of 15 mc/s with benzene and carbon disulphide.

The relative light energy in the various orders of the diffracted beam is being measured. The aim is to find out whether the loss of energy in the central beam due to diffraction, is equal to the sum of energies in the higher order of diffracted beam.

### A. 3.

A. 3.1. *Setting up of a Neutron Generator*

A paper entitled "The Focussing and Magnetic Analysis of a beam from a Radiofrequency Ion Source" has been published in the *Indian Journal of Physics* (October, 1953).

The ion source described in the above mentioned paper, in conjunction with a high voltage accelerator will be used to generate an intense source of high energy neutrons, utilizing deuterium/tritium compounds as targets.

A high voltage source for 150 kv. obtained by voltage doubling



An accelerator tube, in which the high voltage can be impressed in three stages, has been set up.

Arrangements are being made to acquire vacuum pumps with higher speed for maintaining better vacuum in the accelerator tube. This will enable a better utilization of the higher voltages being generated in the laboratory.

#### A. 3.2. *Radiofrequency Generator for high D.C. Voltages*

The 1 kw oscillator at 100 kc/sec., together with the tank coil and high Q. coil has been operating satisfactorily. The voltage developed across the high Q. coil has exceeded the estimate of 10 kv, so that the usable voltage per stage of multiplication is now limited only by the voltage ratings of the condensers and rectifiers of the multiplication circuit. Each unit consists of two condensers in series having an effective rating of 0.025  $\mu$ fd and 20 kv working voltage, and three rectifiers in series with total working voltage of 17 kv at 5 mA. An eight fold multiplication, of the voltage, has resulted in developing a total voltage of 80 kv.

Work is in progress for increasing the multiplication factor to 24 in which case a total voltage of 240 kilovolts is expected to be developed. The condensers for the additional stages have already arrived and the rectifiers are also expected to be received soon. The 24 stages will be arranged in four stacks. A model, for visualization of circuit details, has been built up.

### A. 4. Cosmic ray investigation

#### A. 4.1. *Ionisation chamber investigations*

A. 4.1.1. The large ionisation chamber of 40 litres has been fitted up for continuous record of cosmic ray intensity at Calcutta. It is covered with lead bricks on the sides and with iron plates of requisite thickness on the top, to cut off the radiation from atmospheric radioactivity. There is an arrangement for compensating the average current produced in the ion chamber. The deflection of a Lindemann electrometer connected with the latter is being recorded photographically.

A. 4.1.2. Employing positive ion collection method, photographic records of cosmic ray bursts have been taken for 200 hours approximately, at Calcutta, with an unshielded ion-chamber (wall thickness—3 mm. of steel, vol. 5 litres) using argon gas at a pressure of about 200 lbs. per sq. inch. The size frequency distribution curve of bursts thus recorded, showed two distinct slopes the first having an exponent 4, is followed after a sharp bend by a less steeper curve



The study of the phenomenon of cosmic ray induced fragmentation burst is being continued since December 1953 at Darjeeling with the same apparatus as was used in Calcutta. The latter is housed in a room covered with a corrugated iron roof with a thin wooden ceiling. Records have been taken with one of the ion chambers (5 litre vol.) in an unshielded condition.

Compared to the record obtained in Calcutta the number of smaller bursts (size  $< 1 \times 10^6$  ions) has increased by more than 10 fold while the larger bursts (size  $> 1 \times 10^6$  ions) has increased by about 3 fold,

It is proposed to shield the ion chambers with lead and paraffin blocks respectively, to find out the nature of the burst inducing rays, responsible for the smaller as well as the larger sized bursts. As mentioned in the previous report, two sets of G.M. counters are being put up in the equatorial plane of the ion chamber, to record simultaneously with the coincidences due to narrow and extended air showers.

The installation and working of the two long thin walled cylindrical brass ion chambers, using an electron collection electrode connected to a fast amplifying arrangement is in progress. This method of fast collection and recording of the electron components of the ions produced, will reduce their recombination to a minimum, and thus will furnish more accurate data on the size frequency distribution, specially in the smaller bursts

#### A. 4.2. *Studies on the mean free path of the nucleonic component of cosmic rays*

The big square cloud chamber constructed here has been operating satisfactorily. We have obtained photographs of showers of nuclear interaction and also mixed showers of nuclear origin. The percentage of purely nuclear events without any soft component has been found to be very low at sea-level. The photographs obtained so far have not been quite satisfactory, as the front plate of perspex has gradually become translucent due to a chemical action with the organic liquid used in chamber for supersaturation. This has delayed the departure of the apparatus to the high altitude laboratory at Darjeeling. We are replacing the front plate by means of special armour plate glass which will arrive within a few weeks, when the apparatus will be transferred to Darjeeling.

#### A. 4.3. *Electromagnet with small cloud chamber—Investigation on the scattering of mu-mesons*

The construction and erection of the large electromagnet is now complete. It has been housed in a specially air-conditioned thin roofed room. The cooling arrangement for its coils is almost complete. The small cloud chamber meant to be worked with this magnet has been fixed



circuits and coincidence units to run this chamber are now under construction. The special problem that we want to take up at the start is to study the scattering of mu-mesons at the low-energy end of the meson spectrum.

#### A. 4.4 *Investigation on the mean lives of muons*

The delayed coincidence technique has been used to observe the decay of a composite beam of positive and negative mu-mesons at sea-level in Al, C, Pb and S absorbers. In cases of Al and S, the points on a semi-logarithmic scale for the time intervals 0.6 to 4.0 musecs. fit two straight lines, one yielding the mean life of the composite beam, and the other that of the positives alone. The composite mean lives are found to be  $1.58 \pm 0.07$ ,  $2.15 \pm 0.09$ ,  $1.48 \pm 0.08$  musecs in Al, C and S respectively. The mean lives of positives in Al, Pb and S are  $2.35 \pm 0.11$ ,  $2.23 \pm 0.09$  and  $2.15 \pm 0.14$  musecs respectively. It has been concluded that the composite mean lives are dependent on Z and decreases with increase of Z. The mean life of the negative in C has also been determined and found to be  $1.93 \pm 0.24$  musecs. From these data the ratio of the positive to negative mu-mesons has been found to be  $0.95 \pm 0.16$ .

The following papers have been sent for publication :

1. The mean lives of positive and negative mu-mesons—*Physical Rev. (In the press.)*
2. The variation of the mean lives of mu-mesons with the atomic number of the absorber—*Trans. Bose Res. Inst., Vol. XIX (In the press.)*

### A. 5. Nuclear Physics

#### A. 5.1. *Determination of total gamma ray absorption cross-section*

In continuation of our previous work, absorption cross-sections of various elements and of their compounds (with atomic number ranging from 12 to 82); have been measured. The geometry of the experimental set up is such as to avoid as far as practicable the effect of scattered radiations. The measured cross-sections show good agreement with the theoretical value, unlike the values obtained by Shimizu *et al.* Measurements are now being continued with energy selective scintillation counting equipment, using RCA 5819 photomultiplier tubes. This energy-selective arrangement ensures practically complete elimination of degenerate secondary photons.

#### A. 5.2 *Anomalous absorption cross-section at large absorber thickness*

Clay and others have reported anomalous absorption cross-section at large absorber thickness (15 to 30 cms. of Pb). This fact has been



secondary radiation. Investigation is proceeding using Pb absorber and Ra and Co<sup>60</sup>  $\gamma$ -rays. An energy selective scintillation counting arrangement is being used.

A. 5.3. *Verification of Klein—Nishina scattering formula*

Measurements are now being taken with lead as scattering substance and Geiger as well as scintillation counters as detectors.

## B. CHEMISTRY

### B. 1. Physical and Bio-chemistry

#### B. 1.1 *Electrophoresis Apparatus*

The work on the construction of the Tiselius apparatus did not proceed at the desired rate owing firstly to the lack of funds and secondly to the non-availability of some of the components in this country. Nevertheless, during the latter half of the year in question, when funds became available, construction of some of the major items was completed. Among the important items which still remain to be taken up or completed are some of the more precision parts and control mechanisms. The present position in regard to the construction of the apparatus is summarised below :

(i) The room in which the apparatus will be housed has been constructed with necessary provisions for air conditioning it.

(ii) The optical bench which constitutes a pair of 20 feet long cylindrical shafts mounted on vibration-proof bases has been set up in the new room. The bench has been levelled with the help of a precision spirit-level and the cast iron mounting plates for holding various parts of the apparatus have been fixed at different positions on the bench.

(iii) The slit for the light source has been constructed and a suitable lamp house has been built. The mercury lamps required for the purpose have been received.

(iv) The thermostatic bath which is to be maintained in the neighbourhood of 4°C has been built with a  $\frac{1}{4}$  H.P. refrigerating unit required to obtain the low temperature.

(v) The construction of the support for the electrode vessels and the electrophoresis cells complete with the rack and pinion device for shifting the various sections of the cells has been completed. All glass electrode vessels (capacity about 800 cc.) and a pair of silver electrodes made of



secondary radiation. Investigation is proceeding using Pb absorber and Ra and  $\text{Co}^{60}$   $\gamma$ -rays. An energy selective scintillation counting arrangement is being used.

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and (c) strychnos have been investigated using the horizontal migration method in citric acid-phosphate buffers of pH values 2.2, 4.0, 6.0 and 8.0. The alkaloids move towards the negative electrode at these pH values. Those belonging to the same group possess almost the same mobilities. Thus the cinchona alkaloids studied form a single spot at 2.2 and 4.0 pH; at higher pH values all others excepting cinchonine form a single spot. The opium alkaloids similarly move close to one another. At pH 6.0 the five alkaloids under investigation separate into three groups, the slowest moving spot being constituted of papaverine and the fastest of morphine and thebaine, and the medium moving spot of narceine and narcotine. The two strychnos alkaloids resolve out at pH's 6.0 and 8.0, strychnine moving a little ahead of brucine.

Since the mobility of each group is sufficiently different from the other the separation of the alkaloids belonging to different groups is not very difficult (result published in *Naturwissenschaften*, 41, 19, 1954).

#### B. 1.5. Paper chromatography of inorganic acids

Chromatograms of chloride, nitrate, nitrite, bicarbonate, bisulphite, carbonate, sulphate and thiosulphate of sodium, were developed one-dimensionally using aqueous mixtures of alcohol, acetone, phenol, pyridine and dioxane. Zinc uranyl acetate was used as the indicating agent. The bivalent ions possess in general lower  $R_f$  values than the monovalent ions but hardly any sequence could be found.

#### B. 1.6. Theory of multiple development in paper chromatography

The conditions under which the multiple development is likely to effect better separation have been both theoretically and experimentally investigated.

If after single development or more, the two constituents travel distances  $d_1$  and  $d_2$  ( $d_2 > d_1$ ) from the original starting point and if in each development the solvent front is allowed to travel a distance  $D$  from the same point, the next development will produce better separation when  $d_1 + d_2 < D$ , poorer separation when  $d_1 + d_2 > D$  and will not affect the distance of separation when  $d_1 + d_2 = D$ .

The above generalisations have been experimentally verified but the experimental values somewhat differ from those calculated on the theoretical basis, owing to the fact that the starting distances from the source of developing solvent on successive developments are different (published in 41st *Proc. Ind. Sci. Cong.*, 1954, 52).

#### B. 1.7. Some physico-chemical aspects of circular paper chromatography

The technique of circular paper chromatography has been studied



has been designed for the purpose in which perfect saturation can be maintained.

The  $R_f$  values of solutes as determined by circular chromatography are, in general, higher than those obtained by the strip technique. Starting the experiments with a paper cross with four arms of uniform width and gradually widening the arms to form a whole circular sheet it has been shown that the  $R_f$  values gradually increase from that close to strip technique which corresponds to the paper cross having uniformly wide arms. It is at once clear that the greater value obtained with circular paper is due to a two-dimensional process becoming effective in the latter (*Curr. Sci.* 1953, 22, 238).

The observed variation of  $R_f$  values in circular chromatography with the distance travelled by the solvent has been shown to be due to lack of necessary saturation and is not a real phenomenon. By maintaining saturation or by using a less volatile solvent, e.g. phenol-water, the  $R_f$  value was found to be almost independent of the distance (*Sci. and Cult.*, 1954, 19, 467).

#### B. 1.8. *Paper chromatography of phosphate esters*

Attempts to use butanol-acetic acid-water as a solvent for the separation of the phosphate esters on the circular chromatogram failed, due to the very low  $R_f$  values of phosphate esters with this developing mixture. Double or triple development improved the separations no doubt but brought in further complications due to breakdown of the labile esters and formation of corresponding inorganic phosphate rings in each development.

Use of the new solvent combinations namely methanol-formic acid-water and methanol-ammonia-water were extremely helpful in this direction. Separations were achieved in case of barium insoluble fraction (ATP, ADP, F-1-6P and P.G.A. used in the present investigations) with the acidic solvent combination and in case of barium soluble and alcohol insoluble fraction (AMP, G-1-P and G-6-P used in this study) with the basic solvent mixture. Separations were distinct and prominent when the mixtures were applied on the periphery of a small circle concentric with the circular chromatogram so that the esters formed arcs or bands. When the solutions were applied at the centre of the paper the circular rings either merged with one another or sometimes were not distinctly visible due to lower intensity. By trial the most suitable compositions of the two solvents were found to be 40 : 5 : 1.5 in case of methanol-formic acid (85%) -water and 30 : 5 : 10 in case of methanol-ammonia (33.7%) -water.

The same solvent combinations have been successfully applied in



technique was followed and development in both directions (distance travelled by the solvent being 30 cm. in each case) was completed in 20 hours. Freshly prepared solutions of phosphate esters were found not to decompose within this period. Use of either acidic or basic solvent as the first solvent caused the separation of the esters belonging to each fraction as well as of all the seven esters in a state of mixture.

*B. 1.9. Study of phosphate metabolism in plants with  $P^{32}$  as tracer*

To study the phosphate metabolism in plants, mung bean (*Phaseolus mungo*) seedlings were allowed to germinate in  $\text{Na}_2\text{HP}^{32}\text{O}_4$  solution for definite periods of time. The germinated seedlings were carefully freed from radioactive solution by thorough washing and the phosphate esters were extracted by the method of Umbreit *et al.* The extract was fractionated into barium soluble and barium insoluble parts. The two fractions were subjected to circular paper chromatography, separately as well as jointly. Multiple development technique with butanol-acetic acid-water as developing solvent was used. The developed chromatogram was kept in contact with an x-ray film for 5-6 days; on development of the film dark concentric rings were obtained due to the strong  $\beta$ -activity of  $P^{32}$ . Though identities of a number of radioactive phosphate esters (as P.G.A., F-1-6-P, ADP, AMP etc) on the autoradiogram could be established, complications arose due to the presence of more than one ring of inorganic phosphates as pointed out in the previous section.

This year the same study has been started with new solvent combinations, namely methanol-formic acid-water and methanol-ammonia-water and with both the techniques of circular chromatography and two-dimensional chromatography. The autoradiograms this time are expected to reveal the pattern of distribution of  $P^{32}$  in the germinated seedling.

## **B. 2. Chemical and Microbiological Studies on Jute Fibres**

*B. 2.1. Studies on the retting of jute : The enzyme system*

In continuation of our work on the isolation of ret-causing fungi from various sources, two more strains of *Aspergillus niger* were obtained---one from rotting tamarind seeds and the other from some retted jute stems. The former was found to be very active on jute stems under sterile conditions.

In the preparation of pectins from jute basts, the filtration of the precipitated pectins was found to be very difficult. Attempts were made to precipitate it with various solvents under different conditions. Acetone slightly acidified with acetic acid proved to be the best reagent which usually threw down the pectin in a solid state.



The polygalacturonase activity of enzymes isolated from the different retting fungi was measured by the well-known cup-plate method usually employed in the study of antibiotics. This gives rapid and almost quantitative results.

The degradation products of the jute pectin by enzyme as well as by mineral and organic acids were always found to be galacturonic acid, the end product of hydrolysis. This was identified by paper chromatography. Attempts to isolate the intermediaries in the process of hydrolysis are yet without success.

The enzyme system from various retting fungi was subjected to paper chromatography. The polygalacturonase factor was found to move with the solvent. Work is being continued to separate the various constituents of the enzyme system responsible for retting.

#### B. 2.2. *Stack-retting*

A few jute sticks were stacked together and an inoculum prepared from the most active strain of retting fungi was sprayed on them. The stacks were kept moistened and examined from time to time. The retting was found to be complete within 4-5 days.

#### B. 2.3. *Inoculum for stack-retting*

Various substances like wheat bran, rice husks etc, were first of all sterilised and then inoculated with the spores of the most active strains. After 4 days the medium together with the growing fungus was sprayed on the stacks of jute stems. Wheat bran was found to be the most active medium.

#### B. 2.4. *Oxidation and subsequent decarboxylation of jute holocellulose*

Hemicelluloses are believed to originate from hexosans by progressive biological oxidation and subsequent decarboxylation. In support of this view various workers have attempted to obtain by means of chemical oxidation and decarboxylation hemicelluloses from hexosans. Jute holocellulose (cellulose associated with hemicellulose) has been found to behave like other holocelluloses. Jute fibres (from *Corchorus olitorius*) were first defatted and then delignified by sodium chloride method. The holocellulose thus obtained was oxidised by means of  $\text{NO}_2$ . The uronic  $\text{CO}_2$  values of the oxidised samples were determined. The calculated carboxyl content ranged from 18.3 to 18.6%. In the case of cellulose this value has been reported to be 25% by Unruh and Kenyon.

It is possible to decarboxylate pectin (a polyuronide) by heating in water under pressure. This method has been applied to oxidised jute holocellulose. The carboxyl content of the autoclaved product



behaviour of the decarboxylation product was similar to that of hemicellulose.

#### B. 2.5. Identification of sugar components of gum arabic

Arabic acid, obtained from gum arabic by acidification, was hydrolysed by formic acid (85%) and the sugars liberated were identified by paper chromatography, using phenol-water as the solvent and aniline hydrogen phthalate as the spraying reagent. Galactose, rhamnose and arabinose were thus identified. There were a few unidentified spots.

### B. 3. Impregnation of bleached jute yarns with suitable synthetic resins

Improvement of wet strength by impregnation of bleached jute yarns with synthetic resins has been reported previously. This work was continued during the year under review. The maximum improvement in wet strength was obtained with cationic melamine resins and amounted to 60% of the original strength of the unbleached yarns. This improvement was due to chemical combination of the hydrophylic carboxyl and hydroxyl groups of bleached jute with the basic amino groups of melamine resins. The resinated yarns stood washing with warm soap solutions.

Microscopic examination of transverse sections of resin impregnated fibres and their controls showed that the resin penetrated into the primary walls and middle lamella, from which lignin had been removed on bleaching. This was evident from the bright thick border around deeply stained (methylene blue) fibres in the sections of the treated yarns. It was inferred that the resins entered into cementing layers uniting the cells, and thus contributed to improvement of wet strength (*Sci. and Cult.*, 19,410, 1954).

Although a certain amount of moisture is necessary for the smooth processing of jute in the mills a lowering of the moisture content would be useful (1) in preventing early deterioration of jute goods, (2) in extending the use of jute containers for hygroscopic materials and (3) in improving electrical and heat insulating properties of jute. For these reasons the resistance of resinated jute yarns to water absorption was investigated. It was observed that the absorption of moisture by bleached yarns was very high. Urea formaldehyde resins lowered this moisture absorption considerably. Still better resistance was obtained by the use of a mixture of urea formaldehyde and aminosilane. The lowest absorption was obtained with melamine resins which also gave the best improvement in wet strength.

The results of the investigation on wet strength and water absorption of resinated bleached yarns have been communicated to *Journal of Indian*



## C. BOTANY

## C. 1. Plant Physiology

C. 1.1. *Investigation into the amino-acid requirement of excised root tissue*

a) In last year's report, stimulatory and inhibitory effects of some of the amino acids on the growth of excised tomato root tip tissue was mentioned. The observations however were based on single seven day growth in the proper medium. Whether the roots responded in the same way to different amino acids through continued week to week passage in the medium was an important question and experiments were undertaken to elucidate it. The experiments revealed more or less the same behaviour of the roots in presence of individual amino acids; the stimulating ones maintaining an 'above average' rate of growth through four different weekly passages, whereas in case of the inhibitory acids the roots were damaged irreversibly. Even in cases of  $\beta$ -alanine and tryptophane which produced a partial inhibition, attempts to grow the inhibited tissue at a subsequent culture passage did not prove successful. The results are given in Table I.

TABLE I

THE INFLUENCE OF SOME AMINO ACIDS ON THE GROWTH OF EXCISED TOMATO ROOTS

| Amino acid.         | Concn. of the amino acid.-<br>mg. per litre. | Growth indices of excised roots. |
|---------------------|----------------------------------------------|----------------------------------|
| None                | nil.                                         | 100.0*                           |
| + Glycine           | 3                                            | 115.1                            |
| + $\alpha$ -alanine | 3                                            | 2.5                              |
| + $\beta$ -alanine  | 1                                            | 69.8                             |
| + l-cystine         | 4.8                                          | 145.1                            |
| + Tryptophane       | 2                                            | 60.3                             |
| do.                 | 0.25                                         | 52.7                             |
| Hydrolysed casein   | 8                                            | 150.5                            |

(\* The average growth of a tip during a week following transference from complete nutrients to a medium free of amino acids is taken as 100.)

b) A critical study of the free and bound amino acid content of these roots and the influence of such amino acids as are present in free state in the roots, on the growth of the roots is but the preliminary step to ascertain whether the growth and physiological character of excised roots growing in an artificial medium is the same as those of the roots in normal field grown plants. With this view experiments were undertaken



roots and how they differ from the same in root and stem tips of field grown plants.

For this purpose, roots grown in artificial culture medium supplied with glycine as the only source of organic nitrogen; also root tips and stem tips from field grown and fresh petri dish germinated seedlings were used. The free amino acids were extracted with 80% alcohol. The residue was acid hydrolysed to break up the bound amino acids. In each case the solution of the amino acids so prepared was analysed by the method of partition paper chromatography. The results are given in Table II.

It is evident that both the free and bound amino acids in root tips from field grown seedlings and excised culture root are more or less the same, whereas the roots from petri dish grown seedlings are somewhat deficient. There is some variation in the free and bound amino acids in stem tips of such seedlings. The observation, that the stem tips of very young seedlings, grown in petri dishes and thriving on the reserve food materials of the seeds, contain the amino acids in free state, whereas mature stem tips contain not all of them in free state, indicate the primary formation of amino acids in the course of peptide synthesis. The corresponding picture in roots is not the same, and this may suggest a different amino acid metabolism in roots. Further work on this subject is in progress.

### C. 1.2. Carrot root culture

It is reported (Gautheret) that root cultures of *Daucus carota* are indifferent to the pH of the nutrient solution and that satisfactory growth occurs in any pH within the range of 3 to 11.5. Experiments were carried out to confirm the validity of this fact in case of carrot roots growing in White's medium. Germination of the carrot seeds, transfer of the root tips, and root culture were all done under aseptic conditions. Carrot roots were grown one each in 50 cc. of White medium at the appropriate pH contained in a 125 cc. Pyrex conical flask, at a temp. of  $25^{\circ} \pm 1^{\circ}$  C. for a period of 10 days without transfer. Longitudinal growth of the roots were taken as the criterion of growth and was recorded by measurement of the length on every alternate day. In the pH ranges used, viz. 4 to 9, best growth was observed between pH 4.4 and 5.4, whereas poorest growth was observed at pH 7 and above. Further experiments were carried out to establish the exact pH value in the range of 4.4 to 5.4 which is optimal for continuous maximum growth. For this purpose root cultures were maintained for 30 days with transfer at the end of 10 days interval. pH 4.6 and 4.8 were found to be the optimal for continued



TABLE II  
FREE AND BOUND AMINO ACIDS IN DIFFERENT ROOT AND STEM TIPS

| AMINO ACIDS                  | Free amino acids      |                            |                       |                            | Bound amino acids     |                            |                       |                            |
|------------------------------|-----------------------|----------------------------|-----------------------|----------------------------|-----------------------|----------------------------|-----------------------|----------------------------|
|                              | Stem Tips             |                            | Root Tips             |                            | Stem Tips             |                            | Root Tips             |                            |
|                              | Petridish<br>Seedling | Field<br>grown<br>Seedling | Petridish<br>Seedling | Field<br>grown<br>Seedling | Petridish<br>Seedling | Field<br>grown<br>Seedling | Petridish<br>Seedling | Field<br>grown<br>Seedling |
| $\alpha$ -alanine            | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| $\beta$ -alanine             | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| $\gamma$ -amino butyric acid | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| Arginine                     | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| Asparagine                   | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| Aspartic Acid                | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| Glutamic acid                | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| Glycine                      | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| Histidine                    | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| L-cystine                    | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| Leucines                     | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| Lysine                       | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| Methionine                   | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| Ornithine                    | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| Proline                      | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| Serine                       | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| Threonine                    | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| Tryptophane                  | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| Tyrosine                     | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| Valine                       | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| Nor-valine (?)               | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| Un-identified X              | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| " Y                          | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |
| " Z                          | +                     | +                          | +                     | +                          | +                     | +                          | +                     | +                          |



### C. 1.3 *Bryophyllum* root culture

It is reported that gall tumours can be grown on tomato roots grown *in vitro* by inoculating the tissue with crown gall organism *Ag. tumefaciens*. As *Bryophyllum* plant is being used in this laboratory in experiments on crown gall problem for the production of stem galls, it was considered worth while examining the possibility of initiating galls on *Bryophyllum* roots maintained in artificial medium. So far there has been no attempt to grow the roots of the plants belonging to the family of *Crassulaceae* in *in vitro* culture. Leaves of the plant were chosen as the source of roots as the seeds were not readily available. The leaf as a source of roots has the advantage of providing a large number of roots having more or less identical physiological conditions.

The leaves were sterilised by treating them with a solution of calcium hypochlorite. Although different concentrations of the solution and different periods of treatment in various combinations were tried, in no case it was possible to obtain roots free from microbial contaminations. High concentration of the sterilising solution did not sterilise the leaves in a short treatment, whereas prolongation of the duration of treatment damaged the leaf primordia.

During the winter, seeds of the *Bryophyllum* plant were collected from the plants grown in the Institute garden. Experiments are to be taken up with roots from these seeds as soon as the dormancy period is over.

### C. 1.4. *Production of bacteria free crown gall tumours*

In the last year's report, mention was made of the experiments carried out on the lines suggested by Riker to obtain bacteria-free tumour tissue suitable for *in vitro* biochemical studies. The chamber for heat treatment, as designed originally, failed to give expected results, and had to be modified considerably in a way as to provide the inoculated plants localised heat treatment. With this modified chamber experiments were carried out with non-inoculated plants and results revealed that though in a few cases the plants were somewhat damaged, most of them revived satisfactorily after the heat treatment. A few experiments were carried out with inoculated plants, treatment being for various periods at 45° C. Although all the plants survived and resumed normal growth, in no case gall tissue formed. This might have been due to the extremely high atmospheric temperature prevailing at the time. It is contemplated to take up the experiment after summer when the temperature is expected to come down moderately. It is hoped that by trying different temperatures, some conclusive results may be obtained. *Bryophyllum* plants are being used as plant host in these studies.



C. 1.5. *New hosts for Ag. tumefaciens producing gall tumours*

Experiments were carried out to find out the host range of the strain of *Ag. tumefaciens* maintained in this laboratory for the production of crown gall. For this purpose 24 plants of different species belonging to 15 different Dicotyledonous families were grown in the field of the Institute. The young plants were inoculated at 3 or 4 different points along the main stem by single needle and multiple needle puncture methods with a 72 hrs. agar plate culture of the causal organism. Out of these plants 9 plant species gave positive results producing galls of different size at the end of different time, while the rest were negative so far as gall production was concerned. In the literature on crown gall problem so far 40 different dicotyledonous families have been reported to be susceptible to crown gall organism. The plant family *Scrophulariaceae*, (garden Snapdragon) *Antirrhinum* as the tested species has not been mentioned before. After confirming the results with 3 or 4 different species of the family the name of this family may be added to the list of susceptible families. The results are summarised in Table III.

TABLE III  
RESPONSE OF PLANTS TO INOCULATION WITH *Ag. tumefaciens*

| No. | Common name of the Plant | Botanical name of the Plant     | Family           | Reaction | Approximate time for visible gall formation |
|-----|--------------------------|---------------------------------|------------------|----------|---------------------------------------------|
| 1)  | Bryophyllum              | <i>Bryophyllum calycinum</i>    | Crassulaceae     | +++      | 30-35 days                                  |
| 2)  | Hollyhock                | <i>Althaea rosea</i>            | Malvaceae        | +++      | 15-20 "                                     |
| 3)  | Nasturtium               | <i>Tropaeolum majus</i>         | Tropaeolaceae    | +++      | 15-20 "                                     |
| 4)  | Snapdragon               | <i>Antirrhinum majus</i>        | Scrophulariaceae | ++       | 20-25 "                                     |
| 5)  | Marigold                 | <i>Tagetes patula</i>           | Compositae       | ++       | 20-25 "                                     |
| 6)  | Sunflower                | <i>Helianthus annuum</i>        | "                | +        | 30-35 "                                     |
| 7)  | Tomato                   | <i>Lycopersicon esculentum</i>  | Solanaceae       | +        | 25-30 "                                     |
| 8)  | Verbena                  | <i>Verbena hortensis</i>        | Verbenaceae      | +        | 30-35 "                                     |
| 9)  | Petunee                  | <i>Petunee hybrida</i>          | Solanaceae       | +        | 30-35 "                                     |
| 10) | Tobacco                  | <i>Nicotiana tabacum</i>        | "                | —        |                                             |
| 11) | Poppy (Garden)           | <i>Eschscholzia californica</i> | Papaveraceae     | —        |                                             |
| 12) | Browallia                | <i>Browallia americana</i>      | Solanaceae       | —        |                                             |
| 13) | Portulaca                | <i>Portulaca pilosa</i>         | Portulacaceae    | —        |                                             |
| 14) | Larkspur                 | <i>Delphinium ajacis</i>        | Ranunculaceae    | —        |                                             |
| 15) | Lupine                   | <i>Lupine</i> sp.               | Papilionaceae    | —        |                                             |
| 16) | Sweet pea                | <i>Lathyrus odoratus</i>        | "                | —        |                                             |
| 17) | Pink                     | <i>Dianthus chinensis</i>       | Caryophyllaceae  | —        |                                             |
| 18) | Phlox                    | <i>Phlox drummondii</i>         | Polemoniaceae    | —        |                                             |
| 19) | Periwinkle               | <i>Vinca rosea</i>              | Apocyanaceae     | —        |                                             |
| 20) | Dahlia                   | <i>Dahlia pinnata</i>           | Compositae       | —        |                                             |
| 21) | Cosmos                   | <i>Cosmos bipinnatus</i>        | "                | —        |                                             |
| 22) | Chrysanthemum            | <i>Chrysanthemum</i> sp.        | "                | —        |                                             |
| 23) | Aster                    | <i>Callistepus chinensis</i>    | "                | —        |                                             |



C. 1.6. *Separation of organic phospho-esters by the method of partition paper chromatography.* (see also B.1.8).

In last year's report it was mentioned that preliminary experiments are on the way to separate the different phospho-esters in plant tissue, by the method of partition paper chromatography. The extraction and separation of the different organic phospho-esters by Barium fractionation method was reported, and paper chromatographic separation was considered as the most suitable technique for the identification of the different components in the fractions. For this purpose a number of important organic phospho-esters appearing as glycolytic intermediates in respiration and photosynthesis were obtained from U.S.A. and these were used in the form of soluble sodium salts for the standardisation of the paper chromatography technique.

Attempts were first made to separate the phosphate esters on circular chromatogram, using butyl alcohol : acetic acid : water as a developing solvent. Results were not very satisfactory as the movements of the esters were very slow compared to the solvent resulting in low  $R_f$  values and insufficient resolution of the compounds. Different solvent mixtures were tried to improve upon the technique. With solvent mixture comprising methanol : formic acid : water, and methanol : ammonia : water in cases of the 'Ba insoluble' fraction and the 'Ba-soluble' fraction respectively, better resolution of the compounds has been achieved. However, in circular chromatography experiments, when the solution was applied at the centre of the paper and the wick feeding the developing solvent was introduced at the centre, resolution of the components was not very satisfactory. In cases where the solutions were applied on the periphery of a circle concentric with the paper and the developing solvent introduced at the centre, separation was much improved; the components appearing in well defined areas concentric with the paper.

Two dimensional chromatograms (ascending) using the acidic and basic solvent mixtures for the two perpendicular runs respectively, were developed using either the acid solvent as the first developer followed by the basic one or vice versa. In either case the chromatogram picture was the same and the results were very satisfactory, as a complete separation of the seven compounds in the mixture of 'Ba-insoluble' and 'Ba-soluble' fractions was effected. The total time period for the development running was about 20 hrs.

C.1.7. *Use of  $P^{32}$  in plant metabolism.*

At present investigations are going on in the study of phosphorus metabolism in plants with the use of  $P^{32}$  as tracer phosphorus. 24 hrs. old seedlings of mung beans are used as the test material in this study.



a total volume of 5 cc. per 50 seedlings, in each experiment), for different periods, at the end of which they are washed carefully free of any unbound  $P^{32}$ . The different phospho-esters were extracted by the method of Barium fractionation and separated into the 'Ba-insoluble' and 'Ba-soluble' fractions. The Ba salts were converted into soluble sodium salts and the solutions analysed by the method of paper chromatography and radioautography.

It is interesting to note that in a short period experiments (1 hr. with  $P^{32}$ ) it is the sugars which imbibe the activity most; glucose-1-phosphate gets the maximum, whereas glucose-6-phosphate, fructose-diphosphate and phosphoglyceric acid are also labelled. Contrary to expectations the nucleotides reveal activity somewhat late. In experiments with longer period (12 hrs. in  $P^{32}$ ) the chromatogram reveal a number of organo-phosphate esters in which ATP, ADP, AMP, G-1-P, F-1-6-P, & PGA can be identified besides a number of compounds which have yet to be confirmed. Further experiments are to be taken up with an oncoming consignment of  $P^{32}$ .

In a few preliminary experiments with the green alga *Chlorella pyrenoidosa*, the cells were allowed to grow in presence of the isotopic phosphate in a nutrient medium for about 8 hrs. in diffuse sunlight. The exposed cells were washed with water by centrifugation and extracted in trichloroacetic acid or 80% alcohol. Radioautography of the chromatograms of the extracts reveal that the TCA extract contain a number of labelled compounds in which the seven known compounds mentioned in the preceding paragraph are present. However, the alcohol extracts do not give any indication of the nucleotides whereas the sugars appear as labelled with  $P^{32}$ . These are but few preliminary experiments and are to be followed up in the next year.

#### C. 1.8. Use of $C^{14}$ in photosynthesis.

For use in these experiments a number of alga were collected, all of them were found to be of the blue green variety. Recently a strain of *Chlorella pyrenoidosa* was obtained through the courtesey of Dr. A. K. Mitra of Allahabad University. Unfortunately the culture was found to be contaminated with bacteria. It has however been freed from the contamination by the usual method of plating and sub-culturing and is being maintained in Beijerinck's medium, pH 5.4 to 5.8, in a state of vigorous growth. Photosynthesis experiments with this *Chlorella* as the test organism and using  $C^{14}O_2$  is to be taken up soon.

Work on a large scale culture of the algae is in progress.

In the meantime experiments were conducted with young leaves



plants belonging to the dicotyledonous and monocotyledonous families respectively. Experiments were carried out in the photosynthesis apparatus of Calvin, in which the leaves, excised and starved for 24 hrs., were allowed to photosynthesise for 24 hrs in an atmosphere of  $C^{14}O_2$ , generated from the reaction of  $BaC^{14}O_3$  and lactic acid *in situ*. Arrangements were made for adequate illumination of the leaves.

After the experiment the chamber was flushed with air and the leaves extracted in boiling 80% ethanol. The extract was concentrated and the compounds analysed by the technique of paper chromatography and radioautography.

In case of tobacco, the extract is found to contain at least five compounds containing the labelled carbon in good quantity whereas two compounds seem to be faintly labelled. Further work on their identification is in progress. The radioautograph of the Canna leaf extract is not ready yet.

C. 1.9. *Quantitative determination of the sap expelled from the pulvinus of Mimosa due to excitatory contraction.*

It has been reported previously that a quantity of sap is expelled from the pulvinus of *Mimosa* during excitatory contraction and that it can be determined quantitatively with the help of a micro-potometer. In the present method a small stem piece with a leaf is detached from the plant. For eliminating transpiration the leaflets are also discarded with a portion of the petiole. The lower end of the stem is mounted in the wide end of an L-shaped capillary tube containing water and sealed water tight with modelling clay. The upper end of the stem and the cut end of the petiole are sealed with collodion flexile. As there is considerable transpiration even in such condition the plant material with a portion of the potometer is enclosed in a thoroughly moist glass chamber, the open end of the potometer tube protruding out for observation of the displacement of the water meniscus. The displacement of the meniscus is followed with a micrometer screw of a travelling microscope which is connected with a writing lever of the recorder for obtaining a magnified record of the expelled sap due to pulvinar contraction. The petiole is connected with a second lever with a waxed silk thread passing through a small hole on the lead of the moist chamber, for recording the mechanical response of the pulvinus. For inducing excitatory contraction of the pulvinus, electric shock is applied from outside the chamber through suitable electrodes. The minimal effective electric shock required has been found to be  $\pm 2$  volts produced by an induction coil.

The volume of water expelled out of the cut end is determined from the length of the displaced water column, and the crosssection of the tube



has been found to be widely variable in different specimens. The order of variations, so far obtained, has been found to be ranging from .008 cu. mm. to .05 cu. mm. In the repeated excitatory contraction of the same pulvinus the difference in the quantity of the expelled water has, however, been found to be very small, and in some cases almost negligible.

The quantity of water reabsorbed during recovery of the leaf has been found to greatly exceed the quantity expelled during contraction. The excess water absorbed during recovery varies between 30 to 800% in different specimens. This indicates that the total quantity of water expelled out of the pulvinus is not wholly ejected through the cut end attached to the potometer. A portion only flows through the potometer and the rest escapes through the pores on the body of the plant. In regaining the loss of turgor in the pulvinus during recovery the entire quantity is reabsorbed from the potometer, and hence the difference. The wide variation in values in different specimens can be attributed to both physical and physiological variations in individual ones.

The plant material used in the experiment has three cut surfaces: the lower and the upper cut ends of the stem, and the cut end of the petiole. So far the expulsion of the sap through the lower cut end of the stem has been described. Next attempt has been made to study the outflow of sap individually through the other two cut ends.

In studying the outflow of sap through the upper cut end of the stem the bent end of the potometer is directed downward, so that, the plant remains oriented in its natural position. In observing the outflow through the cut end of the petiole the bent end of the potometer has to be placed horizontally. The branch of the plant from which the specimen is taken requires to be fixed at an inclined position for twenty-four hours, so that, the leaf may be oriented in the desired position suitable for recording the contractile movement of the pulvinus.

The quantity of outflow through the upper cut end of the stem has been very small in comparison to the quantity absorbed in recovery, the difference obtained till now varies from 700 to 1300%. This indicates that greater resistance is encountered in outflowing the sap through the upper cut end of the stem and as a result the major quantity escapes through the pores of the plant body.

The quantity of outflow has been the greatest through the cut end of the petiole and as a result, the difference between the expulsion and reabsorption of water has been very small. It has been found to vary between 8 to 30% only in different specimens. From comparison of the quantitative values of the three outlets it can be definitely stated that outflow through the cut end of the petiole encounters the least



C.1.10. *Study on the effect of contractile response on the respiration of Mimosa.*

The experiment had to be conducted, under certain limitations, with the help of a micro-respirometer previously described. The whole leaf could not be used in the observation because, in such condition the rate of respiration was so high that the oil meniscus left the range of observation long before the recovery of the leaf. Therefore, in the conduction of the experiment the leaflets were discarded and a pulvinus petiole preparation was used. In this condition the normal rate of respiration though greatly reduced, no change of rate could be detected during the contractile response of the pulvinus. Attempts were also made by allowing a few leaflets to remain with the petiole; but the leaflets did not open with the recovery of the pulvinus and remained close even under fluorescent lamp illumination.

Further attempt will be made by introducing certain modifications to the apparatus and the method of experiment.

C. 1.11. *Study of the growth of Avena coleoptile.*

A device has been made for automatically taking the diurnal record of the growth of the *Avena* coleoptile and studying its changes under different conditions. A very small aluminium cone has been fixed at one end of the writing lever. The tip of the coleoptile pushes its head through the cone and the growth is recorded by the other arm of the lever. By this method true record of growth could be obtained of the coleoptile up to the bursting of the tip, in seeded and deseeded conditions and also of the isolated coleoptile tube. The stock of seed was old so the experiment was not continued beyond the preliminary observation. The experiment will be continued this year when fresh seed will be available from the Indian Agric. Res. Inst., New Delhi.

C.1.12. (a) *Role of auxin on the growth of root.* The observation has been made by taking continuous records of growth changes by an automatic device. The growth of root is increased by 31.6 to 67.5 %, within twenty-four hours of decapitation by .75 mm. By decapitation of 1 mm. the growth decreases and stops within twenty -four hours. By reheading immediately after decapitation the effects of tip removal are annulled. It has been found from anatomical studies that in removing .75 mm. and 1 mm. of the tip the same kinds of tissues are affected, the difference being only quantitative. Direct application of auxin at the tip induces only retardation of growth even in very low concentrations. Auxin in high concentration when applied at the hypocotyl much away from the growing region of the root, accelerates the rate of growth. It has been concluded that the acceleration of growth has been brought about by the withdrawal of natural hormone from the tip by the attraction of high concentration auxin applied away from it.



(b) *Viability of vegetable seeds in storage.* It has been found that costly vegetable seeds like carrot, cabbage, cauliflower and knolkhol can be successfully stored for a long time in normal temperature conditions, only by reducing their water content. In open storage condition the seeds lose their viability by absorbing atmospheric moisture within nine months. In sealed storage the viability is progressively increased with the lowering of the water content. Seeds preserved in desiccator have maintained their viability as long as eight years. In the desiccator the loss of moisture content of the seeds has been very rapid for the first few months but later it has become very slow. The seeds in the desiccator have retained about 3% moisture at the termination of eight years. During deterioration of the seed the radicle has been found to be first affected.

C. 1.13. *The following investigations are being undertaken :-*

a) Study of the diurnal variation of the moto-excitability of Mimosa and its correlation with environmental and other factors.

A device has been completed for introducing an electric shock automatically at intervals of one hour and recording the responses for twenty four hours.

b) Study on the relation of electric potential with growth and tropism in plant.

It has been observed by others that a definite polarity and potential difference exist in the growing zone and that a definite potential difference is initiated during various tropic curvatures. The object of the study is to observe whether introduction of similar E.M.F. from outside can bring about similar growth and tropic reaction.

## C. 2. Plant Breeding and Cytogenetics

C. 2.1. *Cotton Breeding Investigations.*

This is a scheme financed by the Government of West Bengal for evolving long stapled cotton types, suitable for cultivation in the deltaic areas of West Bengal and is in the ninth year of investigation, during the year under report.

This report contains two years data i.e. from July 1952 to June 1953 and July 1953 to March 1954. In the previous report, the data collected up to the end of March 1953 only were included. Due to the "staggering sowing" of the previous year, some of the important data



could be collected only after March 1953. But these data will have to be considered in relation to the previous findings and hence the necessity for the inclusion of two years data in the present report. The data for the year 1953-54, will be completed only by June 1954, which will be included in the next report.

The sowing season of 1953 was fairly favourable, with moderate rainfall and therefore the germination was satisfactory. But the heavy rainfall towards the end of the sowing season affected the stand; also the insect pests increased, which may also be due to the fact that quite a number of the established plants of the previous season were also growing in the field.

Detailed studies were made of 406 strains including 30 parent types, 307 hybrids from the  $F_4$  to the  $F_{10}$  generations, the rest being reciprocal, cyclic and multiple crosses from the  $F_4$  to the  $F_{10}$  generations. Many fresh hybridizations were not made during this year, as it was found necessary to study in detail the breeding behaviour of the hybrids already made and only these could be undertaken, with the limited staff available in the scheme. But certain backcrosses, cyclic and multiple crosses were made as planned previously. Nearly all the types were sown in replications and inspite of the fact that cotton was being grown in the same fields year after year for the last 9 years without rotation or heavy manuring, the results obtained appear to be favourable. A few more desirable hybrids were selected during the year in addition to the ones previously selected and their behaviour under field conditions with respect to the maximum number of bolls produced by best plant, the average number of bolls produced in each type, the lint length, ginning percentage, the number of days required for the first flush in 1952-53, 1953-54 and the difference between these, were calculated and are contained in Table 1. In addition, the "Parbhani American" recommended as one of the types suitable for cultivation under the conditions in West Bengal by the Directorate of Agriculture, was again grown and its data has also been included along with the others.

It will be seen that most of the varieties took a longer time to flower in 1952-53 than in the next year. This may be due to the adverse effect of silt which was put into the fields for raising the level, during the first season when the plants were found to be stunted in growth after a month. These fields were therefore treated with a light dressing of lime and cowdung manure and the plants revived there-after. It therefore appears that silt is harmful to the growth of the cotton plants, as it probably makes the soil very "heavy".

The spacings given were as usual—3ft between rows, and 9" between plants. This closer spacing will give more plant per unit area and also



TABLE. I.

| Type    | SL. No. | Names                                                       | Maximum No. of bolls harvested from one plant | Average No. of bolls harvested per plant in the type | Lint length in mm. | Ginning per-centage | No. of days required for the first flush of flowers in 1952-53 | No. of days required for the first flush of flowers in 1953-54 | Difference in period in flush- ing in 1953-54 from 1952-53 |
|---------|---------|-------------------------------------------------------------|-----------------------------------------------|------------------------------------------------------|--------------------|---------------------|----------------------------------------------------------------|----------------------------------------------------------------|------------------------------------------------------------|
| Percent |         |                                                             |                                               |                                                      |                    |                     |                                                                |                                                                |                                                            |
|         | 1.      | K-1                                                         | 69                                            | 12.66                                                | 31.5               | 33.40               | 118                                                            | 118                                                            | 0                                                          |
|         | 2.      | 7682                                                        | 34                                            | 15.00                                                | 34.5               | 37.64               | 87                                                             | 98                                                             | + 11                                                       |
|         | 3.      | 7682-14-E <sub>2</sub>                                      | 38                                            | 12.81                                                | 35.5               | 35.69               | 85                                                             | 101                                                            | - 16                                                       |
|         | 4.      | $7682.21 \times \{CO_4 \times (SG \times SI)\} \times 4456$ | 35                                            | 11.66                                                | 31.5               | 35.99               | 104                                                            | 97                                                             | + 7                                                        |
|         | 5.      | $7733D32e4 \times (CO_3 \times CO_4)Rush Ash \times SG Ash$ | 72                                            | 16.07                                                | 32.0               | 33.97               | 92                                                             | 85                                                             | + 7                                                        |
|         | 6.      | 5286 BVI                                                    | 33                                            | 11.12                                                | 31.5               | 36.36               | 92                                                             | 97                                                             | + 5                                                        |
|         | 7.      | LSS                                                         | 54                                            | 11.31                                                | 35.0               | 35.18               | 94                                                             | 97                                                             | - 3                                                        |
|         | 8.      | 4F                                                          | 36                                            | 13.91                                                | 34.0               | 36.07               | 93                                                             | 84                                                             | + 9                                                        |
|         | 9.      | $CO_4 - B4O - 21$                                           | 78                                            | 16.91                                                | 33.5               | 36.75               | 90                                                             | 80                                                             | + 10                                                       |
|         | 10.     | $CO_2$                                                      | 33                                            | 13.12                                                | 33.5               | 33.69               | 91                                                             | 96                                                             | - 5                                                        |
|         | 11.     | Purbhani American                                           | 25                                            | 12.30                                                | 31.5               | 32.00               | 125                                                            | 109                                                            | + 16                                                       |
|         | 1.      | LSS X 4F                                                    | 32                                            | 14.03                                                | 34.5               | 39.93               | 83                                                             | 81                                                             | + 2                                                        |
|         | 2.      | $920 X 4F$                                                  | 34                                            | 16.12                                                | 34.0               | 35.43               | 85                                                             | 70                                                             | + 15                                                       |
|         | 3.      | $920 X CO_2$                                                | 38                                            | 12.22                                                | 32.0               | 37.14               | 96                                                             | 94                                                             | + 2                                                        |
|         | 4.      | $CO_3 X 920$                                                | 37                                            | 10.08                                                | 33.5               | 34.16               | 146                                                            | 77                                                             | + 69                                                       |
|         | 5.      | $CO_2 X 4F$                                                 | 56                                            | 22.34                                                | 35.0               | 35.75               | 76                                                             | 69                                                             | + 7                                                        |
|         | 1.      | $7625 - 1 IX CO_2$                                          | 33                                            | 13.64                                                | 33.5               | 35.71               | 160                                                            | 107                                                            | + 53                                                       |
|         | 2.      | $7727G_3 IX 6097C_6$                                        | 31                                            | 16.34                                                | 33.5               | 38.10               | 96                                                             | 85                                                             | + 11                                                       |
|         | 3.      | $7727G_3 IX CO_3$                                           | 34                                            | 15.00                                                | 34.0               | 38.39               | 95                                                             | 93                                                             | + 2                                                        |
|         | 4.      | $6097C_6 IX 7625 - 1$                                       | 44                                            | 14.49                                                | 31.0               | 35.29               | 147                                                            | 85                                                             | + 62                                                       |
|         | 5.      | $6097C_6 IX CO_2$                                           | 30                                            | 15.95                                                | 34.5               | 35.50               | 98                                                             | 75                                                             | + 23                                                       |
|         | 6.      | LSS IX 4F                                                   | 30                                            | 16.84                                                | 35.0               | 36.40               | 116                                                            | 82                                                             | + 34                                                       |
|         | 7.      | $289F IX 4463$                                              | 45                                            | 19.61                                                | 31.5               | 34.50               | 98                                                             | 99                                                             | - 1                                                        |



TABLE I. (Contd.)

| Type            | Sl. No. | Names                                                                         | Maximum No. of bolls harvested from one plant | Average No. of bolls harvested per plant in the type | Lint length in mm. | Ginning percentage | No. of days required for the first flush of flowers in 1952-53 | No. of days required for the first flush of flowers in 1953-54 | Difference in period of flushing in 1953-54 from 1952-53 |
|-----------------|---------|-------------------------------------------------------------------------------|-----------------------------------------------|------------------------------------------------------|--------------------|--------------------|----------------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------|
| RF <sub>9</sub> | 8.      | 4463 IX 6113F <sub>2</sub>                                                    | 34                                            | 16.71                                                | 35.5               | 36.36              | 119                                                            | 112                                                            | + 7                                                      |
|                 | 9.      | 4463 IX 289F <sub>124</sub>                                                   | 51                                            | 20.71                                                | 35.0               | 38.10              | 103                                                            | 97                                                             | + 6                                                      |
|                 | 10.     | CO <sub>2</sub> IX 4463                                                       | 48                                            | 19.20                                                | 33.0               | 38.10              | 109                                                            | 88                                                             | + 21                                                     |
| RF <sub>8</sub> | 1.      | (CO <sub>3</sub> -4463) IX CO <sub>3</sub>                                    | 40                                            | 27.00                                                | 32.5               | 35.71              | 126                                                            | 93                                                             | + 33                                                     |
|                 | 1.      | 5286BV <sub>1</sub> VIII.4F                                                   | 36                                            | 22.83                                                | 34.0               | 36.36              | 205                                                            | 87                                                             | + 118                                                    |
|                 | 2.      | 7733-8.VIII.CO <sub>2</sub>                                                   | 47                                            | 22.00                                                | 35.0               | 35.00              | 149                                                            | 84                                                             | + 65                                                     |
|                 | 3.      | 6113F <sub>2</sub> . VIII. LSS                                                | 44                                            | 27.20                                                | 33.0               | 33.33              | 137                                                            | 96                                                             | + 41                                                     |
|                 | 4.      | 6113F <sub>2</sub> . VIII. CO <sub>2</sub>                                    | 55                                            | 40.20                                                | 31.5               | 34.07              | 143                                                            | 84                                                             | + 59                                                     |
|                 | 5.      | 7727G <sub>3</sub> . VIII. CO <sub>2</sub>                                    | 96                                            | 47.67                                                | 32.5               | 35.71              | 221                                                            | 91                                                             | + 130                                                    |
|                 | 6.      | CO <sub>4</sub> . VIII. 920                                                   | 45                                            | 26.19                                                | 32.0               | 34.78              | 103                                                            | 68                                                             | + 35                                                     |
| RF <sub>7</sub> | 7.      | CO <sub>3</sub> . VIII. 289F <sub>43</sub>                                    | 81                                            | 39.33                                                | 32.0               | 36.36              | 132                                                            | 77                                                             | + 55                                                     |
|                 | 8.      | CO <sub>2</sub> . VIII. 4F                                                    | 78                                            | 59.33                                                | 32.0               | 35.00              | 159                                                            | 86                                                             | + 73                                                     |
|                 | 9.      | CO <sub>2</sub> . VIII. LSS                                                   | 62                                            | 32.75                                                | 33.0               | 37.50              | 149                                                            | 117                                                            | + 32                                                     |
|                 | 10.     | CO <sub>2</sub> . VIII. 4F                                                    | 44                                            | 28.33                                                | 35.0               | 38.46              | 85                                                             | 89                                                             | - 4                                                      |
| RF <sub>5</sub> | 1.      | (6113F <sub>2</sub> × 7625-1). VIII. (920-LSS)                                | 44                                            | 27.10                                                | 33.0               | 34.38              | 133                                                            | 92                                                             | + 41                                                     |
|                 | 2.      | (CO <sub>3</sub> × 5286BV <sub>1</sub> ). VIII. 920                           | 53                                            | 37.00                                                | 32.0               | 40.00              | 114                                                            | 91                                                             | + 23                                                     |
|                 | 3.      | (CO <sub>3</sub> × CO <sub>2</sub> ) - (CO <sub>3</sub> × 4F). VI. (920II-4F) | 55                                            | 54.50                                                | 32.5               | 37.50              | 117                                                            | 104                                                            | + 13                                                     |
|                 | 4.      | (CO <sub>3</sub> × 4463). VIII. (CO <sub>4</sub> -LSS)                        | 40                                            | 21.71                                                | 35.0               | 35.71              | 92                                                             | 78                                                             | + 14                                                     |
| RF <sub>6</sub> | 1.      | (7727G <sub>3</sub> × 4463). VIII. 4463                                       | 43                                            | 25.71                                                | 32.0               | 34.78              | 106                                                            | 116                                                            | - 10                                                     |
|                 | 2.      | (289F × 4463). VIII. 289F <sub>43</sub>                                       | 37                                            | 10.39                                                | 33.0               | 37.50              | 207                                                            | 111                                                            | + 96                                                     |
|                 | 3.      | (CO <sub>3</sub> × CO <sub>2</sub> ). VIII. CO <sub>2</sub>                   | 32                                            | 21.40                                                | 31.5               | 35.00              | 96                                                             | 123                                                            | - 27                                                     |



TABLE I. (Contd.)

| Sl. No. | Names                                                         | Maximum No. of bolls harvested from one plant | Average No. of bolls harvested per plant in the type | Lint length in mm. | Ginning percentage | No. of days required for the first flush of flowers in 1952-53 | No. of days required for the first flush of flowers in 1953-54 | Difference in period of flushing in 1953-54 from 1952-53 |
|---------|---------------------------------------------------------------|-----------------------------------------------|------------------------------------------------------|--------------------|--------------------|----------------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------|
| 1.      | 6097C <sub>6</sub> VII. 5286BVI                               | 38                                            | 25.38                                                | 31.0               | 34.78              | 108                                                            | 97                                                             | + 11                                                     |
| 2.      | LSS. VII. 5286BVI                                             | 37                                            | 19.09                                                | 32.5               | 37.50              | 133                                                            | 95                                                             | + 38                                                     |
| 3.      | CO <sub>2</sub> VII. 5286BVI                                  | 38                                            | 29.00                                                | 34.0               | 34.78              | 111                                                            | 90                                                             | + 21                                                     |
| 4.      | 7733-8. VII. 7625-1                                           | 39                                            | 23.45                                                | 32.5               | 40.00              | 87                                                             | 97                                                             | - 10                                                     |
| 5.      | 289F. VII. 7625-1                                             | 41                                            | 17.70                                                | 32.0               | 37.50              | 105                                                            | 88                                                             | + 17                                                     |
| 6.      | 4463. VII. 7625-1                                             | 37                                            | 19.88                                                | 30.0               | 38.46              | 85                                                             | 94                                                             | - 9                                                      |
| 7.      | 289F. VII. 7733-8                                             | 39                                            | 12.86                                                | 32.5               | 38.10              | 95                                                             | 83                                                             | + 12                                                     |
| 8.      | 7733-8. VII. 289F                                             | 32                                            | 15.25                                                | 31.0               | 40.00              | 98                                                             | 111                                                            | - 13                                                     |
| 9       | CO <sub>4</sub> VII. 289F                                     | 32                                            | 18.71                                                | 32.5               | 36.36              | 126                                                            | 72                                                             | + 54                                                     |
| 10.     | [7733D32e × (CO <sub>3</sub> × CO <sub>4</sub> ). R.A. SG.A]  | 56                                            | 29.77                                                | 35.0               | 35.49              | 140                                                            | 102                                                            | + 38                                                     |
| 11.     | 77338. VII. 289F                                              | 42                                            | 18.39                                                | 31.5               | 38.10              | 103                                                            | 84                                                             | + 19                                                     |
| 12.     | 6097C <sub>6</sub> VII. 4F                                    | 114                                           | 24.77                                                | 33.5               | 37.50              | 124                                                            | 123                                                            | + 1                                                      |
| 13.     | [7682-21 × (CO <sub>4</sub> × (SG × SI) × 4456]. VII. 4463    | 32                                            | 16.55                                                | 34.0               | 33.33              | 124                                                            | 110                                                            | + 14                                                     |
| 14.     | 6097C <sub>6</sub> VII. 4463                                  | 33                                            | 15.40                                                | 31.5               | 38.46              | 131                                                            | 94                                                             | + 37                                                     |
| 15.     | LSS. VII. 4463                                                | 44                                            | 19.55                                                | 30.0               | 35.48              | 107                                                            | 86                                                             | + 21                                                     |
| 16.     | [7733D32e4 × (CO <sub>3</sub> × CO <sub>4</sub> ). R.A. SG.A] | 35                                            | 16.26                                                | 32.5               | 36.36              | 114                                                            | 130                                                            | + 14                                                     |
| 17.     | 6097C <sub>6</sub> VII. 920                                   | 39                                            | 20.86                                                | 31.5               | 36.00              | 108                                                            | 104                                                            | + 4                                                      |
| 18.     | 7625-1. VII. CO <sub>4</sub>                                  | 39                                            | 15.37                                                | 35.5               | 33.33              | 118                                                            | 80                                                             | + 38                                                     |



TABLE I. (Contd.)

| Type             | Sl. No. | Names                                                                                 | Maximum No. of bolls harvested from one plant | Average No. of bolls harvested per plant in the type | Lint length in mm. | Ginning percentage | No. of days required for the first flush of flowers in 1952-53 | No. of days required for the first flush of flowers in 1953-54 | Difference in period of flushing in 1953-54 from 1952-53 |
|------------------|---------|---------------------------------------------------------------------------------------|-----------------------------------------------|------------------------------------------------------|--------------------|--------------------|----------------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------|
|                  | 19.     | 7727G <sub>3</sub> , VII. CO <sub>3</sub>                                             | 32                                            | 20.18                                                | 30.5               | 39.29              | 133                                                            | 99                                                             | + 34                                                     |
|                  | 20.     | CO <sub>4</sub> , VII. CO <sub>3</sub>                                                | 40                                            | 25.68                                                | 31.5               | 35.71              | 118                                                            | 122                                                            | - 4                                                      |
|                  | 21.     | [7733D32e4 × (CO <sub>3</sub> × CO <sub>4</sub> ) × R.A. SG.A.], VII. CO <sub>2</sub> | 51                                            | 28.40                                                | 30.0               | 36.36              | 97                                                             | 121                                                            | - 24                                                     |
|                  | 22.     | 289F, VII. CO <sub>2</sub><br>124                                                     | 38                                            | 16.33                                                | 30.0               | 37.03              | 126                                                            | 77                                                             | + 49                                                     |
|                  | 23.     | CO <sub>4</sub> , VII. CO <sub>2</sub>                                                | 33                                            | 24.50                                                | 32.0               | 36.00              | 133                                                            | 79                                                             | + 54                                                     |
|                  | 24.     | [7733D32e4 × (CO <sub>3</sub> × CO <sub>4</sub> ) R.A. SG.A.], VII. 7036              | 74                                            | 21.88                                                | 30.5               | 38.43              | 150                                                            | 129                                                            | + 21                                                     |
|                  | 1.      | 6097C <sub>6</sub> , V. (CO <sub>2</sub> ≡4F)                                         | 36                                            | 18.45                                                | 30.0               | 36.67              | 110                                                            | 118                                                            | - 8                                                      |
|                  | 2.      | 289F, V. (CO <sub>2</sub> ≡4F)<br>124                                                 | 36                                            | 15.63                                                | 31.0               | 36.36              | 125                                                            | 88                                                             | + 37                                                     |
|                  | 3.      | CO <sub>4</sub> , V. (CO <sub>2</sub> ≡4F)                                            | 63                                            | 24.78                                                | 35.0               | 38.71              | 134                                                            | 94                                                             | + 40                                                     |
|                  | 4.      | CO <sub>3</sub> , V. (CO <sub>2</sub> ≡4F)                                            | 36                                            | 18.27                                                | 31.0               | 37.50              | 103                                                            | 116                                                            | - 13                                                     |
|                  | 5.      | (CO <sub>4</sub> -CO <sub>2</sub> ), V. (CO <sub>2</sub> ≡4F)                         | 46                                            | 33.50                                                | 35.5               | 34.15              | 114                                                            | 118                                                            | - 4                                                      |
|                  | 6.      | (CO <sub>2</sub> =CO <sub>4</sub> ), V. (CO <sub>2</sub> ≡4F)                         | 34                                            | 16.68                                                | 35.5               | 35.29              | 113                                                            | 117                                                            | - 4                                                      |
|                  | 7.      | [289F-(289F-CO <sub>2</sub> )], V. (CO <sub>2</sub> ≡4F)<br>43 43                     | 130                                           | 54.00                                                | 32.0               | 34.71              | 112                                                            | 146                                                            | - 34                                                     |
|                  | 1.      | (CO <sub>2</sub> ≡4F), IV. 14E <sub>2</sub>                                           | 125                                           | 101.50                                               | 31.0               | 39.29              | 111                                                            | 101                                                            | + 10                                                     |
|                  | 2.      | CO <sub>4</sub> B40.21, IV. 7682                                                      | 63                                            | 55.00                                                | 31.0               | 36.36              | 107                                                            | 105                                                            | + 2                                                      |
|                  | 3.      | 5286 BVI, IV. 7682                                                                    | 65                                            | 38.71                                                | 30.5               | 40.00              | 120                                                            | 115                                                            | + 5                                                      |
|                  | 4.      | 7682-18B, IV. 5286BVI                                                                 | 68                                            | 44.33                                                | 32.5               | 35.00              | 176                                                            | 126                                                            | + 50                                                     |
|                  | 5.      | 7682, IV. 6097C <sub>6</sub>                                                          | 61                                            | 40.80                                                | 35.0               | 33.86              | 115                                                            | 124                                                            | - 9                                                      |
|                  | 6.      | CO <sub>4</sub> , IV. LSS                                                             | 48                                            | 26.00                                                | 34.0               | 38.71              | 179                                                            | 95                                                             | - 84                                                     |
|                  | 7.      | 4F, IV. CO <sub>2</sub>                                                               | 30                                            | 26.40                                                | 33.0               | 33.33              | 178                                                            | 123                                                            | + 55                                                     |
| iiF <sub>1</sub> | 1.      | 289F, VI(CO <sub>3</sub> × 289F)<br>4 43                                              | 38                                            | 22.09                                                | 31.5               | 34.69              | 115                                                            | 79                                                             | + 36                                                     |



The Sea Island type thrived successfully in the shades, and were crossed with the other economic types. Among the hybrid seeds obtained, many were not viable and those that grew into the seedling stage did not survive long.

Fresh hybridizations were again attempted during the current year as the Sea Island type has very good lint length ( $2\frac{1}{2}$ "'), but with a low ginning percentage, as it will be desirable if some of the better qualities of this type can be transferred to the other economic types. But this is rather difficult, as the lint length and the ginning percentage are negatively correlated.

It will be noticed from the Table 1 that among the 11 parent types listed CO<sub>4</sub>-B40-21, has the maximum number of bolls in its best plant viz. 78, as against 25 bolls in Parbhani—American. The latter has a low lint length (31.5 mm) and the lowest ginning percentage, viz. 32% among the parent types. Type CO<sub>4</sub>-B40-21 has the best average yield (average of all the plants in the population and its lint length and ginning percentage (average of 10 readings from the population) are also favourable. But there are a number of hybrids with better yields, ginning percentages and lint length, and which are also earlier than CO<sub>4</sub>-B40-21.

A detailed study of the table will reveal many interesting features regarding the parent types and the hybrids, but it is proposed to briefly mention only a few of them here.

Among the hybrids in the F<sub>10</sub> generation, CO<sub>2</sub> X 4F has the maximum number of bolls and the best average, namely 56 and 22.34. Its lint length is 35.0 mm with a ginning percentage of 35.75, which are also quite favourable. Moreover, these are sufficiently early; 76 days in the first year and 69 in the second and hence this appears to be a good type.

Among the F<sub>9</sub> hybrids, 4463 IX,  $\frac{289F}{124}$  appear to have the largest number of bolls in its best plant and the best average, viz. 51 and 20.71. Its length is 35.0 mm with 38.1 ginning percentage, which are also quite favourable. This type in the 52-53 season is reasonably early taking 97 days for its first flush.

Among the hybrids in the F<sub>8</sub> generation, 7727G<sub>3</sub>. VIII. CO<sub>2</sub> has 96 bolls in its best plant with an average of 47.67 and with a lint length of 32.5 mm and a ginning percentage of 35.71. This took 91 days in the season 53-54 for the first flush. This is favourable, except for its lint length, which is lower than many other types, but higher than the Parbhani-American.

Among the multiple crosses in the 8th generation, type [(CO<sub>3</sub> ×



TABLE 2. (Contd.)

| Type                      | Sl. No. | Names | Treatments | Maximum No. of bolls per plant in each treatment | Difference from control | Ginning Percentage % of each treatment | Difference from control | Lint Length in mm. in each treatment | Difference from control |
|---------------------------|---------|-------|------------|--------------------------------------------------|-------------------------|----------------------------------------|-------------------------|--------------------------------------|-------------------------|
| CO <sub>2</sub>           |         |       | Control    | 22                                               | —                       | 34.48                                  | —                       | 33.5                                 | —                       |
|                           |         |       | 5 m.a.H.   | 25                                               | +3                      | 34.29                                  | -0.19                   | 33.5                                 | ±0                      |
|                           |         |       | 10 m.a.H.  | 23                                               | +1                      | 37.84                                  | +3.36                   | 33.0                                 | -0.5                    |
| CO <sub>2</sub>           |         |       | 15 m.a.H.  | 25                                               | +3                      | 35.75                                  | +1.27                   | 34.0                                 | +0.5                    |
|                           |         |       | Control    | 17                                               | —                       | 34.00                                  | —                       | 33.5                                 | —                       |
|                           |         |       | 5 m.a.H.   | 19                                               | +2                      | 34.69                                  | +0.69                   | 34.0                                 | +0.5                    |
| CO <sub>2</sub>           |         |       | 10 m.a.H.  | 32                                               | +15                     | 39.39                                  | +5.39                   | 33.5                                 | ±0                      |
|                           |         |       | 15 m.a.H.  | 25                                               | +8                      | 35.11                                  | +1.11                   | 33.0                                 | -0.5                    |
| CO <sub>2</sub>           |         |       | Control    | 20                                               | —                       | 34.04                                  | —                       | 34.0                                 | —                       |
|                           |         |       | 5 m.a.H.   | 35                                               | +15                     | 35.61                                  | +1.57                   | 35.0                                 | +1.0                    |
|                           |         |       | 10 m.a.H.  | 33                                               | +13                     | 37.18                                  | +3.14                   | 35.5                                 | +1.5                    |
| LSS. IX. 4F               |         |       | 15 m.a.H.  | 21                                               | +1                      | 35.33                                  | +1.29                   | 35.0                                 | —                       |
|                           |         |       | Control    | 36                                               | —                       | 36.00                                  | —                       | 34.5                                 | —                       |
|                           |         |       | 5 m.a.H.   | 20                                               | -16                     | 36.00                                  | ±0                      | 34.0                                 | -0.5                    |
| 920. IX. 4F               |         |       | 10 m.a.H.  | 21                                               | -15                     | 37.11                                  | +1.11                   | 34.0                                 | -0.5                    |
|                           |         |       | 15 m.a.H.  | 24                                               | -12                     | 38.64                                  | +2.64                   | 34.5                                 | ±0                      |
|                           |         |       | Control    | 29                                               | —                       | 35.48                                  | —                       | 33.5                                 | —                       |
| CO <sub>2</sub> . IX. LSS |         |       | 5 m.a.H.   | 43                                               | +14                     | 36.54                                  | +1.06                   | 33.5                                 | ±0                      |
|                           |         |       | 10 m.a.H.  | 31                                               | +2                      | 37.01                                  | +1.53                   | 33.5                                 | ±0                      |
|                           |         |       | 15 m.a.H.  | 29                                               | ±0                      | 33.45                                  | -0.03                   | 35.0                                 | +1.5                    |
| CO <sub>2</sub> . IX. 920 |         |       | Control    | 27                                               | —                       | 36.36                                  | —                       | 34.0                                 | —                       |
|                           |         |       | 5 m.a.H.   | 22                                               | -5                      | 36.46                                  | +0.10                   | 33.5                                 | -0.5                    |
|                           |         |       | 10 m.a.H.  | 30                                               | +3                      | 36.17                                  | -0.19                   | 34.5                                 | +0.5                    |
| CO <sub>2</sub> . IX. 4F  |         |       | 15 m.a.H.  | 36                                               | +9                      | 34.21                                  | -2.15                   | 34.0                                 | ±0                      |
|                           |         |       | Control    | 21                                               | —                       | 36.17                                  | —                       | 33.5                                 | —                       |
|                           |         |       | 5 m.a.H.   | 43                                               | +22                     | 37.50                                  | +1.33                   | 33.0                                 | -0.5                    |
| CO <sub>2</sub> . IX. 4F  |         |       | 10 m.a.H.  | 19                                               | -2                      | 36.67                                  | +0.50                   | 33.0                                 | -0.5                    |
|                           |         |       | 15 m.a.H.  | 20                                               | -1                      | 34.09                                  | -2.08                   | 33.5                                 | +0.5                    |
| CO <sub>2</sub> . IX. 4F  |         |       | Control    | 20                                               | —                       | 36.66                                  | —                       | 34.5                                 | —                       |
|                           |         |       | 5 m.a.H.   | 24                                               | +4                      | 37.84                                  | +1.18                   | 34.5                                 | ±0                      |
|                           |         |       | 10 m.a.H.  | 27                                               | +7                      | 37.81                                  | +1.15                   | 35.0                                 | +0.5                    |
| CO <sub>2</sub> . IX. 4F  |         |       | 15 m.a.H.  | 32                                               | +12                     | 37.78                                  | +1.12                   | 34.5                                 | ±0                      |
|                           |         |       | Control    | 20                                               | —                       | 36.66                                  | —                       | 34.5                                 | —                       |
|                           |         |       | 5 m.a.H.   | 24                                               | +4                      | 37.84                                  | +1.18                   | 34.5                                 | ±0                      |
|                           |         |       | 10 m.a.H.  | 27                                               | +7                      | 37.81                                  | +1.15                   | 35.0                                 | +0.5                    |
|                           |         |       | 15 m.a.H.  | 32                                               | +12                     | 37.78                                  | +1.12                   | 34.5                                 | ±0                      |



TABLE 2.

| Type                                                               | Sl. No. | Names | Treatments | Maximum No. of bolls per plant in each treatment | Difference from control | Ginning Percentage % of each treatment | Difference from control | Lint Length in each treatment in mm. | Difference from control |
|--------------------------------------------------------------------|---------|-------|------------|--------------------------------------------------|-------------------------|----------------------------------------|-------------------------|--------------------------------------|-------------------------|
| 7682                                                               |         |       | Control    | 25                                               | —                       | 35.28                                  | —                       | 35.0                                 | —                       |
|                                                                    |         |       | 5 m.a.H.   | 36                                               | +11                     | 35.36                                  | +0.08                   | 35.5                                 | +0.5                    |
|                                                                    |         |       | 10 m.a.H.  | 26                                               | +1                      | 39.29                                  | +4.01                   | 35.0                                 | ±0                      |
|                                                                    |         |       | 15 m.a.H.  | 38                                               | +13                     | 35.97                                  | +0.69                   | 35.0                                 | ±0                      |
| 7682—18B                                                           |         |       | Control    | 18                                               | —                       | 36.36                                  | —                       | 35.0                                 | —                       |
|                                                                    |         |       | 5 m.a.H.   | 40                                               | +22                     | 36.00                                  | -0.36                   | 35.5                                 | +0.5                    |
|                                                                    |         |       | 10 m.a.H.  | 28                                               | +10                     | 38.78                                  | +2.42                   | 34.5                                 | -0.5                    |
|                                                                    |         |       | 15 m.a.H.  | 20                                               | +2                      | 37.54                                  | +1.18                   | 35.5                                 | +0.5                    |
| 7682—14—E <sub>2</sub>                                             |         |       | Control    | 29                                               | —                       | 34.78                                  | —                       | 35.0                                 | —                       |
|                                                                    |         |       | 5 m.a.H.   | 21                                               | -8                      | 33.33                                  | -1.45                   | 35.5                                 | +0.5                    |
|                                                                    |         |       | 10 m.a.H.  | 48                                               | +19                     | 34.26                                  | -0.52                   | 35.0                                 | ±0                      |
|                                                                    |         |       | 15 m.a.H.  | 22                                               | -7                      | 39.47                                  | +4.69                   | 36.0                                 | +1                      |
| 7682—21 × {CO <sub>2</sub> × (SG × SI)} × 4456                     |         |       | Control    | 27                                               | —                       | 35.61                                  | —                       | 33.5                                 | —                       |
|                                                                    |         |       | 5 m.a.H.   | 29                                               | +2                      | 39.68                                  | +4.07                   | 35.5                                 | ±0                      |
|                                                                    |         |       | 10 m.a.H.  | 31                                               | +4                      | 35.82                                  | +0.21                   | 33.0                                 | -0.5                    |
|                                                                    |         |       | 15 m.a.H.  | 28                                               | +1                      | 35.38                                  | -0.23                   | 33.5                                 | ±0                      |
| 7733D32e × (CO <sub>2</sub> × CO <sub>4</sub> ) × Rush Ash.SG.Ash. |         |       | Control    | 25                                               | —                       | 36.11                                  | —                       | 34.0                                 | —                       |
|                                                                    |         |       | 5 m.a.H.   | 26                                               | +1                      | 36.66                                  | +0.55                   | 34.0                                 | ±0                      |
|                                                                    |         |       | 10 m.a.H.  | 30                                               | +5                      | 38.78                                  | +2.67                   | 34.0                                 | ±0                      |
|                                                                    |         |       | 15 m.a.H.  | 26                                               | +1                      | 35.71                                  | -0.40                   | 34.0                                 | ±0                      |
| 4F                                                                 |         |       | Control    | 29                                               | —                       | 36.43                                  | —                       | 34.5                                 | —                       |
|                                                                    |         |       | 5 m.a.H.   | 32                                               | +3                      | 38.58                                  | +2.15                   | 34.5                                 | ±0                      |
|                                                                    |         |       | 10 m.a.H.  | 32                                               | +3                      | 36.31                                  | -0.12                   | 35.0                                 | +0.5                    |
|                                                                    |         |       | 15 m.a.H.  | 35                                               | +6                      | 38.10                                  | +1.67                   | 34.0                                 | -0.5                    |
| 920                                                                |         |       | Control    | 19                                               | —                       | 34.69                                  | —                       | 32.0                                 | —                       |
|                                                                    |         |       | 5 m.a.H.   | 20                                               | +1                      | 35.71                                  | +1.02                   | 32.5                                 | +0.5                    |
|                                                                    |         |       | 10 m.a.H.  | 26                                               | +7                      | 35.90                                  | +1.21                   | 33.5                                 | +1.5                    |
|                                                                    |         |       | 15 m.a.H.  | 51                                               | +32                     | 34.57                                  | -0.12                   | 31.5                                 | -0.5                    |
| CO <sub>2</sub> B40.21                                             |         |       | Control    | 19                                               | —                       | 35.00                                  | —                       | 35.0                                 | —                       |
|                                                                    |         |       | 5 m.a.H.   | 27                                               | +8                      | 36.90                                  | +1.90                   | 34.5                                 | -0.5                    |
|                                                                    |         |       | 10 m.a.H.  | 26                                               | +7                      | 36.33                                  | +1.33                   | 34.5                                 | -0.5                    |
|                                                                    |         |       | 15 m.a.H.  | 51                                               | +32                     | 34.57                                  | -0.12                   | 31.5                                 | -0.5                    |



average of **54.5**. Its lint length is 32.5 mm., and its ginning percentage is 37.5. But it is a late type.

Among the hybrids in the  $F_7$  generation, type 6097C6.VII.4F has **114** bolls on its best plant, but its average yield is low. But its lint length and ginning percentage are quite favourable, viz. 33.5 mm and 37.5%. But this is a late type. The best average yield is from type [7733D32e4  $\times$  ( $\text{CO}_3 \times \text{CO}_4$ )  $\times$  R.A.SG.A.] VII.CO<sub>2</sub> where they have 28.4 bolls. Although its length is low, its ginning percentage is favourable. This is also a comparatively late type.

Among the hybrids in the  $F_4$  generation, ( $\text{CO}_2$ -4F) IV.7682-14-E<sub>2</sub> has the largest number of bolls viz. **125** with an average yield of **101.5**, *which is also very high*. Its lint length is comparatively low (31.0 mm) its ginning percentage is very good, viz. **39.29**. This is one of the medium types as regards duration.

There are a number of types which are not very favourable under the climatic and soil conditions existing at Falta. But some of these may prove very useful elsewhere; in fact they may be better than many of the types listed in the table. Hence it is necessary to give field trials for these types under as many divergent environmental conditions as possible; it may be mentioned here that some of our better types did very well under the environmental conditions in Tripura.

The irradiation experiments were continued during the year under report with 16 types and the results are contained in Table II. The treatments given were 5, 10 and 15 m.a.Hs. to seeds in the dry state and were sown in replications, with a control in each plot. It will be seen that there is very little difference in the lint length between the treatments and the controls, but the yield and the ginning percentages have increased in many of the types, in some cases considerably. For example, in type 7682, while the best plant in the control had only 25 bolls, one plant selected from the 15 m.a.H. treatment had 38 bolls; *an increase of  $1\frac{1}{2}$  times*. Again, the ginning percentage in the control of this type is 35.28, while one plant in the 10 m.a.H. treatment had 39.29, an increase of 4.01 or 11.3%. In type 7682-18B, while the control had only 18 bolls, one plant selected from the 5 m.a.H. treatment had **40** bolls, *which is more than double*. In this type, while the control had a ginning percentage of 36.36, the best plant in the treatment had 38.78, an increase of 2.42 or 66%. In type 7682-14-E<sub>2</sub>, the increase in yield in the selection from the 10 m.a.H. treatment is over  $1\frac{1}{2}$  times and ginning percentage in the 15 m.a.H. treatment is 13.4% more than in the control. In type 7682-21  $\times$  { $\text{CO}_4 \times (\text{SG} \times \text{SI})$ }  $\times$  4456 the selections from the 10 m.a.H treatment has **31** bolls as against 27 in the control. The gin-



as against 35.61, or an increase of **4.07** or **11.4%**. Similarly, the selected plants from the treatments in 7733D32e4  $\times$  ( $\text{CO}_3 \times \text{CO}_4$ ) Rush. Ash. SG. Ash. and 4F, registered an increase both in the yield and the ginning percentages, the latter by **7.3%** and 5.9% over the controls. In type 920, the selected plant from the 15 m.a.H. treatment has **51** bolls as against 19 in the control, an increase of over **2½** times. Here, the ginning percentage has increased from 34.69 to 35.90 in the 10 m.a.H. treatment or an increase of **3.4%** only. In type  $\text{CO}_4$ -B40-21, the increase in the number of bolls is nearly **1½** times over the control in the 10 m.a.H. treatment, and in the 15 m.a.H. treatment, the ginning percentage has increased by 2.5 or 7.1%. In type  $\text{CO}_4$ , the treatments show a slight increase in the number of bolls, but there is an appreciable increase in the ginning percentage in the 10 m.a.H. treatment viz. from 34.48 to 37.84 or an increase of 9.7%. In  $\text{CO}_3$ , the selection from the 10 m.a.H. treatment has nearly *double* the number of bolls than in the control and the ginning percentage registered an increase of 5.39 or 15.8%. In  $\text{CO}_2$ , while the best plant in the control had only 20 bolls, one plant in the 5 m.a.H. treatment produced 35 *bolls*, which is twice the yield over the control. The ginning percentage increased in this type in one of the treatments by 9.2%. In the hybrid type LSS IX 4F, the best plant in the control had a greater number of bolls than the best in the treatments, but the ginning percentage in the 15 m.a.H. treatment is more than in the control, viz. 2.64 or an increase of **7.3%**. In the hybrid type 920 IX 4F, one plant in the 5 m.a.H. treatment has **43** bolls as against 23 in the control, an increase of *nearly 1½* times. The ginning percentage in two of the treatments are also greater than in the control, the maximum being 4.2%. The hybrid type  $\text{CO}_4$  IX LSS also registered an increase in the number of bolls in two treatments, but the ginning percentage has slightly increased only in one treatment (.25%), which is negligible. The hybrid type  $\text{CO}_3$  IX 920 has *double the number of bolls* in the 5 m.a.H. treatment, while the ginning percentage in this has also increased from 36.17 to 37.5 or by 3.6%. In the hybrid type  $\text{CO}_2$  IX 4F, the 15 m.a.H. treatment registered an increase of nearly **1½** times in the number of bolls, than in the control, and in the 5 m.a.H. treatment, the ginning percentage has increased from 36.66 to 37.84 or 3.2 %.

It will thus be noticed that in 15 types out of the 16, there has been increase in yield, in one by as much as nearly 3 *times* over the control. The ginning percentage also increased in all the types in one treatment and/or the other, the maximum being 15.8% over the control, in  $\text{CO}_3$ . During this year, type 920 gave the maximum increase in yield (*nearly 3 times*) while the same was one of the three types of the previous year which gave an increased yield of 3 times over the control.

When the increase in ginning percentage are considered in relation



7682-18B, 7733D32e4  $\times$  ( $\text{CO}_3 \times \text{CO}_4$ )  $\times$  R. Ash  $\times$  SG. Ash.,  $\text{CO}_4$ ,  $\text{CO}_3$  and  $\text{CO}_2$  have given increased ginning of 11.3%, 6.6%, 7.3%, 9.7%, **15.8%** and 9.2% respectively over these controls. The 5 m.a.H. treatments have increased ginning by 11.4% and 5.9% in types 7682-21  $\times$  ( $\text{CO}_4 \times (\text{SG} \times \text{Sl}) \times 4456$  and 4F respectively. The 15 m.a.H. treatments have increased the ginning by 13.4%, 7.1% and 7.3%, in types 7682-14-E<sub>2</sub>,  $\text{CO}_4$ -B4O-21 and LSS IX 4F respectively. Therefore, the results of the X-radiation results during the year under report appears to be very favourable and the performances of the progenies of these have to be studied during the next season without any further treatments for assessing the practical value of these results.

Table 3 gives a list of the type grown during the year, which are early. They are arranged according to their dates of flowering the earliest being listed first. Many of these also have high yields with good lint length and ginning percentage and hence are listed in Table I also. It will be seen that the hybrid type  $\text{CO}_3$  VIII 920 in the  $F_8$  generation is the earliest, the first flush appearing in 67 days. There are ten hybrid types which flower on the 90th day listed at the bottom of the table, of which 7 are in the  $F_7$  generation and 3 in the  $F_5$  generation. The performances of some of these should now be tried under different environmental conditions.

The three hybrid types evolved by crossing the tree cottons as the male parent with the economic types such as 920  $\times$  4F ( $F_4$ ), 920  $\times$  LSS ( $F_4$ ) and LSS  $\times$  4F( $F_4$ ) are in the  $F_5$  generation during the year under report. Back crossing were attempted to induce more of the qualities of the female parents and at present, the vegetative characters such as size and shape of leaves, branching and heights of the plants and the characters of the fruits like their size and the arrangements of the seeds in the locules are more like the female parents, although in the  $F_1$  hybrids they were more like the male parent. But the shape of the bolls are more like the male parent. Mention may be made of the cross with LSS  $\times$  4F( $F_4$ ) which gave a comparatively good yield this year, with a lint length of 30.5 mm and a ginning percentage of 32.43, and it took 78 days to flower. But the fiber is still coarse like the male parent and repeated backcrosses will have to be done to improve this factor, if at all possible.



## D. MICROBIOLOGY

The following items of investigation were undertaken during the year under review :

1. Further studies on the occurrence of antibiotic producing actinomycetes from the soils of India
2. Role of antibiotics in soil.
3. Control of *H. oryzae* by antibiotics and antibiotic producing organisms.
4. Investigation into the production of Vitamin B<sub>12</sub> by micro-organisms.
5. Studies on the production of an antifungal antibiotic by a *Streptomyces* sp.
6. Production of an antibiotic substance by a *Streptomyces* sp. active against gram-positive bacteria.
7. Further studies on the antibiotic produced by Ac<sub>3</sub>(203).
8. Effect of antibiotics and isonicotinic acid hydrazides on *Nocardia madurae*.
9. (a) Setting up of the apparatus for counter-current distribution  
(b) Studies on the physico-chemical aspects of counter-current distribution.

### D.1. Further studies on the occurrence of antibiotic producing actinomycetes from the soils of India.

Investigations were continued on the survey of antibiotic producing micro-organisms from the soils of India with special reference to *Streptomyces* spp. elaborating antifungal substances.

Altogether 196 strains isolated from 60 soil samples collected from different parts of India were screened against 6 phytopathogenic fungi and 5 bacterial test organisms. These included *Helminthosporium oryzae*, *Curvularia* sp., *Verticillium* sp., *Fusarium* sp., *Aspergillus oryzae* and *Alternaria solani* among fungi and *Staphylococcus aureus*, *Bacillus subtilis*, *Bacillus cereus* var. *mycoides*, *Eberthella typhosa* and *Escherichia coli* among bacteria. Of the 196 strains assayed by the cross-streak method, 128 showed activity against one or more fungi and 93 against one or more bacterial test organisms (Table I). The positive strains were then cultivated in modified straw-infusion broth to find out if the antibiotics were also produced in liquid medium. Only 29 strains were found to be positive by the subsequent cup-plate assay of the culture fluid against two susceptible strains of *Curvularia* sp. and *Aspergillus niger*. Results of a few promising strains



The results obtained from these studies go to support the view of earlier workers that the distribution of antifungal property amongst soil *Streptomyces spp.* is a widespread phenomenon. From Table III showing the distribution of action of the *Streptomyces spp.* against particular species of the test fungus, it is quite apparent that while *Fusarium sp.* and *Verticillium sp.* are more or less resistant to the action of antibiotics, *H. oryzae*, *Curvularia sp.*, *A. oryzae* etc. are susceptible. This is true at least for the strains of test fungi used by us.

With the data at hand it may be suggested, although without any assertion, that the *Streptomyces spp.* may play some important role in the control of plant pathogenic fungi in soil. Investigation regarding the production of antibiotic substances by *Streptomyces spp.* in soil has been undertaken, and met with some success. The results are put forward in the following section.

TABLE I.

DISTRIBUTION OF ANTIBIOTIC PROPERTY AMONG *Streptomyces* STRAINS

| No. of soil samples analysed | No. of strains tested by the cross-streak method | No. of strains showing positive action against |                                          |            |
|------------------------------|--------------------------------------------------|------------------------------------------------|------------------------------------------|------------|
|                              |                                                  | Gram-positive bacteria                         | Gram-positive and Gram-negative bacteria | Test fungi |
| 60                           | 196                                              | 69                                             | 93                                       | 128        |

TABLE II.

ANTIFUNGAL ACTIVITY OF SOME PROMISING *Streptomyces* STRAINS

| Streptomyces strains | Inhibition zone in mm. as assayed by the cup-plate method against |                          |
|----------------------|-------------------------------------------------------------------|--------------------------|
|                      | <i>Curvularia sp.</i>                                             | <i>Aspergillus niger</i> |
| Ac <sub>1</sub> 220  | 20.5                                                              | 15.5                     |
| Ac <sub>1</sub> 245  | 21.5                                                              | 0.0                      |
| Ac <sub>1</sub> 246  | 21.0                                                              | 18.0                     |
| Ac <sub>1</sub> 247  | 18.0                                                              | 0.0                      |
| Ac <sub>1</sub> 248  | 25.0                                                              | 22.0                     |
| Ac <sub>1</sub> 249  | 20.0                                                              | 27.0                     |



TABLE III.

DISTRIBUTION OF ANTIFUNGAL ACTION AGAINST DIFFERENT TEST FUNGI

|                                                   | <i>Alternaria solani</i> | <i>Verticillium sp.</i> | <i>Helmintho. oryzae</i> | <i>Aspergillus oryzae</i> | <i>Curvularia sp.</i> |    |
|---------------------------------------------------|--------------------------|-------------------------|--------------------------|---------------------------|-----------------------|----|
| No. of strains showing antagonistic action        | 29                       | 20                      | 33                       | 48                        | 42                    | 28 |
| No. of strains showing strong antagonistic action | 8                        | 10                      | 11                       | 20                        | 16                    | 4  |

## D.2. Role of Antibiotics in Soil

### D. 2.1. Fate of pure antibiotics in soil:

Fate of dihydro-streptomycin sulphate and chloromycetin in soil was studied. Solutions of the two antibiotics were mixed with definite amounts of soil in such proportions as to give finally the concentrations of 0.25, 0.5 and 1 mg of the antibiotics per unit mass of the soil. The soil aliquots in conical flasks were kept at room temperature and the rate of recovery of the antibiotics was studied by the standard perfusion technique at definite intervals. The resulting soil solutions were tested against *E. coli*. Plotting the values of the diameter of inhibition zones in standard dosage-response curves of the two antibiotics, the rates of recovery were calculated.

(a) Streptomycin -soil solutions derived from aliquots containing 0.25 mg/gm of soil were inactive against *E. coli* after 48 hours and from those containing 0.5 mg/gm, after 72 hours. With higher concentrations however, the activity was retained for longer time.

(b) Chloromycetin -Soil solutions derived from all the aliquots showed activity for a longer period of time than those of streptomycin-containing soils, although the activity showed a gradual fall from a maximum recorded on the 1st and 2nd days.

Alongside the above observations were studied the effects of the two antibiotics on the soil microflora by the usual dilution plate technique from the treated soil aliquots. It was observed that in the case of streptomycin treated soils, the density of the bacterial flora recorded a remarkable decrease, reaching a maximum in 48 hours. After 72 hours, there was no further fall in the microbial concentration. In the case of chloromycetin, on the other hand, there was a steady decrease in the microflora upto the 6th day beyond which the observation was not continued. These results are in agreement with those obtained from



D. 2.2. *Studies with the antibiotic producing strains of Streptomyces in soil*

Investigations were also undertaken to determine whether the antibiotic producing strains of *Streptomyces* could produce antibiotics in the natural soil. Two well-known strains were selected for the purpose. These were *S. griseus*, which produced streptomycin and *S. venezuelae*, which produced chloromycetin. Both the antibiotics in pure form had already been studied as to their behaviour in soil.

Spore suspensions of the two organisms were thoroughly mixed with definite amounts of soil aliquots in conical flasks and kept at room temperature. Soil solutions from these by the perfusion technique were assayed against *E. coli* and rates of recovery recorded as in the previous experiment. The effect on soil microflora was also studied as before. It was observed that by neither method the results showed that the strains produced antibiotics in the soil. When, however, the soil was supplemented by organic nutrients like 1.5% glucose and 3.5% paddy straw dust, *S. venezuelae* was found to produce some antibiotic presumably chloromycetin, in the soil. This could be detected by the assay of the soil solution against *E. coli* and decrease in the number of micro-organisms in that soil as determined by the dilution plate technique. *S. griseus*, however, failed to produce any detectable amount of antibiotic even in the supplemented soil.

D. 2.3. *Control of Helminthosporium oryzae by antibiotic producing organism.*

Ac<sub>6</sub> (125), a strain of *Streptomyces sp.* related to *S. griseus*, was found to possess strong antifungal properties when grown in liquid culture media. When assayed against *H. oryzae*, a pathogen on paddy plant, the strain exhibited strong inhibitory action as tested by agar-cup method of assay. It was also found by soil solution method that Ac<sub>6</sub>(125) produced inhibitory substance in soil, when grown along with 3.5% paddy straw and 1.5% glucose but failed to do so, when the organic nutrients were not added to soil. Some paddy (*Oryza sativa*) seedling of Bhutmari variety, 3 days old, were transferred to sterile soil in glass jars, 9"×5" in dimension, containing about 500 gm of soil. The seeds, prior to germination, were sterilised with mercuric chloride for 2 minutes and transferred to sterile petri-dishes containing moist filter paper for germination. Thus germinated, the plants were allowed to grow for 5 days and 25 ml. of conidial suspension of *H. oryzae* were added to four jars, while the same amount of suspension of *Streptomyces sp.* was added to two of the four jars already inoculated with *H. oryzae*. Of the remaining jars, two contained conidial suspensions of *Streptomyces sp.* only, while the rest were kept apart for observation under controlled conditions. The plants were allowed to grow and sterile tap water was added from time



after 20 days that normal growth occurred in all the cases except those inoculated with *H. oryzae*. Only in the case of jars inoculated with *H. oryzae* it was observed that some spots appeared on the leaves which were gradually dried up. *H. oryzae* also affected the growth of plants which became stunted in appearance. The above observations indicate the possibility of the use of suitable antibiotics and antibiotic producing organisms as a means of control of plant diseases. Further investigation on the control of pathogenicity of *H. oryzae* and its antagonism by Ac (125) is in progress.

### D. 3 Investigation into the production of Vitamin B<sub>12</sub> by Micro-organisms

#### I *Streptomyces* Spp.

Since the publication of reports about the ability of the strains of *S. chromogenes*, *S. griseus*, and *S. antibioticus* to produce vitamin B<sub>12</sub>, a number of surveys have reported other strains of the genus *Streptomyces* to be good producers of this vitamin. Some of the strains of this genus isolated in this laboratory, mainly as a part of the general survey of the microbiological flora of Indian soil specially with regard to the production of antibiotic substances, were simultaneously screened for the production of vitamin B<sub>12</sub>.

The strains were grown in Dey's modified medium (1946) supplemented by CoCl<sub>2</sub>, 6H<sub>2</sub>O (2 parts per million) for 8 days at 28°C and tested according to the method of Cuthbertson and co-workers (1951), using a strain of *E. coli* mutant as the test organism.

Of the 80 strains tested for vitamin B<sub>12</sub> production, 48 showed positive activity. It was also found that there was apparently no relation between the production of antibiotics and that of vitamin B<sub>12</sub>. Tests were run simultaneously to check by means of paper chromatography, the production of methionine as a metabolite which was also known to give response to the growth of the test organism.

Of the isolates, strains belonging to *S. fradiae*, *S. californicus*, 8-80 group, characterised according to Gottlieb and Pridham (1948) were found to elaborate different amounts of vitamin B<sub>12</sub> under identical conditions of fermentation.

Further study on the choice of media and selective conditions of fermentation by the most potent strains is in progress, with the aim of investigating into the metabolic pathway of *Streptomyces* spp. specially in relation to the production of vitamin B<sub>12</sub> by means of tracer technique,



#### D.4. Studies on the production of an antifungal antibiotic by a *Streptomyces* sp.

Of the 29 strains found positive by the cup-plate assay method against *Curvularia* sp. and *Aspergillus niger*, one strain, Ac<sub>4</sub>(248), was selected for further investigations regarding isolation and partial purification of the antibiotic principle elaborated by it and its systematic identification.

Ac<sub>4</sub>(248), an unidentified strain of *Streptomyces* sp. was isolated from a soil sample collected from Darjeeling in November, 1953. A study of its morphological and physiological characteristics showed that the strain was related to *Streptomyces griseus*. The strain produced in modified straw infusion dextrose broth, an antibiotic substance which turned the beer highly active against a large number of fungi. The culture fluid had, however, no activity against any of the bacterial test organisms. As *Streptomyces griseus* also elaborates a highly antifungal antibiotic—actidione, a comparative study was made regarding the antifungal spectra of actidione (Res. No. 9207, the Upjohn Company, Michigan) and the culture liquid of Ac<sub>4</sub>(248) (Table IV).

The crude culture filtrate of Ac<sub>4</sub>(248) contained more than 100 dilution units of the antibiotic substance against *Curvularia* sp. when the organism was grown in stationary culture in modified straw-infusion dextrose broth at pH 7.4. The activity reached a maximum on the 8th day and remains unaltered for about 30 days. When subjected to a temperature of 100° C for 30 minutes, the culture filtrate lost half its activity.

From a comparative study by means of the bio-autographic technique, using n-butanol-acetic acid-water (4:1:1), water-saturated chloroform and n-butanol-chloroform (1:1), it appeared that the culture liquid of Ac<sub>4</sub>(248) might contain more than one antibiotic principle and that one of these might be identical with actidione produced by *Streptomyces griseus*. Further investigations to prove the identity of the substance by using actidione-resistant yeast strains have recently been undertaken.

Attempts made to isolate the antibiotic by liquid extraction using chloroform were partly successful. On evaporation of the solvent under vacuo, dark brown colored mass was obtained with activity ten times as great as the parent culture fluid. The active substance was found to be adsorbed by Norit's activated charcoal SBX 30 from the culture fluid at pH 7.0. A suitable eluant is still to be found. Various polar and nonpolar solvents were tried without much success.



TABLE IV.

COMPARISON OF ANTIFUNGAL SPECTRA OF ACTIDIONE AND CRUDE CULTURE  
FILTRATE OF AC<sub>4</sub>(248)

| Test fungi                            | Actidione | Ac <sub>4</sub> (248) |
|---------------------------------------|-----------|-----------------------|
| <i>Saccharomyces cerevisiae</i> .. .. | +         | +                     |
| <i>Curvularia specifera</i> .. ..     | —         | +                     |
| <i>Penicillium steckii</i> .. ..      | —         | +                     |
| <i>Helminthosporium oryzae</i> .. ..  | +         | +                     |
| <i>Penicillium notatum</i> .. ..      | +         | +                     |
| <i>Alternaria solani</i> .. ..        | —         | +                     |
| <i>Verticillium sp.</i> .. ..         | +         | —                     |
| <i>Fusarium sp.</i> .. ..             | +         | —                     |

#### D.5. Production of an antibiotic substance by a *Streptomyces* sp. active against gram-positive bacteria

A strain of *Streptomyces* sp. isolated from Dehra Dun forest soil was found to be antibiotically active against gram-positive bacteria on preliminary screening. The strain was grown in Czapek-Dox liquid culture media for 8 days at 28°-30°C and the culture filtrate was found to be active against *S. aureus*, *Enterococcus* and *B. subtilis* even at a dilution of 1 in 100 by agar cup method of assay. It was also observed that in course of fermentation, the beer attained a deep purplish colour at the end of the 8th day. The pigment was extracted by means of ether at a pH below 2.5 and after evaporation, a red pigment was left behind. This was dissolved in a minimum amount of alcohol at an acidic pH, re-extracted with ether and the whole operation was repeated till a red powder was obtained. The substance was found to be active against gram-positive bacteria.

The pigment was red in solutions of pH 3.0 or less, purple at pH near 7.0 and blue at pH near or above 9.0. The substance was soluble in water in the alkaline pH, 5% NaHCO<sub>3</sub> and NaOH.

Qualitative tests suggested the anthocyanin nature of the substance. On reduction with Zn dust in dil. acetic acid, the pigment became colorless. On aeration, the solution regained its colour.

On comparison with allied substances having antagonistic action, it was found to resemble litmanidin and litmanidin.



however, was reported to be elaborated by a *Proactinomyces* sp. The substance described by us differed from coelicolorin in certain respects especially in its behaviour towards alkali. No further confirmatory evidence could be given for the lack of comprehensive data in literature in the case of Litmocidin and Coelicolorin. Further study on the identity and properties of the substance is in progress.

#### **D.6. Further studies on the antibiotic substance produced by *Ac<sub>3</sub>*(203)**

The purified antibiotic gave no colouration with  $\text{FeCl}_3$ . It gave negative tests with 2-4-dinitro-phenyl hydrazine and Fehling's solution. The Elson-Morgan test was not responded. It was found to be strongly sensitive to ninhydrin reagent. The purified product was analysed as sulphate after drying *in vacuo* at  $60^\circ\text{C}$ . Found -C 27.2 H 6.21 N 6.9 Res 23.5. The infrared studies in cyclohexanol and Nujol indicated the polypeptide nature. The substance was hydrolysed with 6N HCl in a sealed tube for 36 hours at  $120^\circ\text{C}$  and the hydrolysate was analysed by means of both one-and two--dimensional paper chromatography using phenol-water and benzyl alcohol-acetic acid-water as developing solvents. Eight spots (one doubtful) were revealed on the chromatogram, the identity of which is now being studied. Further study on degradation products is in progress.

From a study of some of the microbiological and chemical properties of the substance it appeared that the substance might belong to neomycin complex. But it was also found that the ratio of activity against *E. coli* to that against *B. subtilis* was different from those described in literature. The substance did not induce resistance to *E. coli* even on 15 transfers.

To test the homogeneity of the substance as also for further purification of the product which still contains considerable amount of residual matter, it is now intended to operate the Counter-current distribution apparatus which has already been set up in this laboratory.

#### **D.7. Study on the effect of antibiotics and isonicotinic acid hydrazides on *Nocardia* (*Actinomyces*) *maduræ***

The above item of investigation has been communicated to the



#### **D.8. (a) The set-up of the apparatus for counter-current distribution**

The apparatus for counter-current distribution was designed after Craig's modified form. It consists of 24 single units made of Pyrex glass. The single units lie interlocked with the exit tube from one unit being inserted into the inlet tube of its neighbour. Each unit consists of an equilibration chamber, of which the volume of the lower part is made 10 cc after several trials. The system can be tilted by a mechanical arrangement and shaken to an angle of  $35^\circ$  on either side until equilibrium is attained so that neither of the phases of the solvents can splash out through the openings. After the phases have been allowed to separate, the unit is tilted to an angle somewhat more than  $90^\circ$ . The upper phase, 10 cc in volume, decants into the upper chamber, while the lower phase remains behind. When the unit is tilted back to the horizontal position, the upper phase in the upper chamber flows into the opening of the adjoining unit of the series. The units of the series are supported individually, the horizontal portion of each unit being attached to the wooden-frame with two brass clamps connected together by means of a tie-rod, while the vertical portion is fixed to its position by a third one. All clamps are movable and each unit can smoothly be held in its proper position. The rotation of the system is now done by means of a handle attached to the wooden frame. This will soon be replaced by an automatic mechanical arrangement.

#### **(b) Studies on the physico-chemical aspects of Counter-current distribution**

The instrument set up in the laboratory was standardised by a study of the distribution of methylene blue in two immiscible solvents—water and n-butanol. Prior to the standardisation the partition coefficient of methylene blue in the above system was found to rise constantly with dilution. The distribution of methylene blue in the solvents mentioned above, as studied in separating funnels by single withdrawal process, was found to obey the binomial expansion theorem, so far as the lower phase was concerned. Then the instrument itself was operated and the distribution in each unit was determined by means of spectro-photometer. It was observed that the resultant curve followed the binomial law within limits of error. So far as is known the counter-current distribution of the dye has not been studied elsewhere. It is proposed to study the



## D. MICROBIOLOGY

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Spore suspensions of the two organisms were thoroughly mixed with definite amounts of soil aliquots in conical flasks and kept at room temperature. Soil solutions from these by the perfusion technique were assayed against *E. coli* and rates of recovery recorded as in the previous experiment. The effect on soil microflora was also studied as before. It was observed that by neither method the results showed that the strains produced antibiotics in the soil. When, however, the soil was supplemented by organic nutrients like 1.5% glucose and 3.5% paddy straw dust, *S. venezuelae* was found to produce some antibiotic presumably chloromycetin, in the soil. This could be detected by the assay of the soil solution against *E. coli* and decrease in the number of micro-organisms in that soil as determined by the dilution plate technique. *S. griseus*, however, failed to produce any detectable amount of antibiotic even in the supplemented soil.

D. 2.3. *Control of Helminthosporium oryzae by antibiotic producing organism.*

Ac<sub>6</sub> (125), a strain of *Streptomyces sp.* related to *S. griseus*, was found to possess strong antifungal properties when grown in liquid culture media. When assayed against *H. oryzae*, a pathogen on paddy plant, the strain exhibited strong inhibitory action as tested by agar-cup method of assay. It was also found by soil solution method that Ac<sub>6</sub>(125) produced inhibitory substance in soil, when grown along with 3.5% paddy straw and 1.5% glucose but failed to do so, when the organic nutrients were not added to soil. Some paddy (*Oryza sativa*) seedling of Bhutmari variety, 3 days old, were transferred to sterile soil in glass jars, 9"×5" in dimension, containing about 500 gm of soil. The seeds, prior to germination, were sterilised with mercuric chloride for 2 minutes and transferred to sterile petri-dishes containing moist filter paper for germination. Thus germinated, the plants were allowed to grow for 5 days and 25 ml. of conidial suspension of *H. oryzae* were added to four jars, while the same amount of suspension of *Streptomyces sp.* was added to two of the four jars already inoculated with *H. oryzae*. Of the remaining jars, two contained conidial suspensions of *Streptomyces sp.* only, while the rest were kept apart for observation under controlled conditions. The plants were allowed to grow and sterile tap water was added from time



after 20 days that normal growth occurred in all the cases except those inoculated with *H. oryzae*. Only in the case of jars inoculated with *H. oryzae* it was observed that some spots appeared on the leaves which were gradually dried up. *H. oryzae* also affected the growth of plants which became stunted in appearance. The above observations indicate the possibility of the use of suitable antibiotics and antibiotic producing organisms as a means of control of plant diseases. Further investigation on the control of pathogenicity of *H. oryzae* and its antagonism by Ac (125) is in progress.

### **D. 3 Investigation into the production of Vitamin B<sub>12</sub> by Micro-organisms**

#### **I *Streptomyces* Spp.**

Since the publication of reports about the ability of the strains of *S. chromogenes*, *S. griseus*, and *S. antibioticus* to produce vitamin B<sub>12</sub>, a number of surveys have reported other strains of the genus *Streptomyces* to be good producers of this vitamin. Some of the strains of this genus isolated in this laboratory, mainly as a part of the general survey of the microbiological flora of Indian soil specially with regard to the production of antibiotic substances, were simultaneously screened for the production of vitamin B<sub>12</sub>.

The strains were grown in Dey's modified medium (1946) supplemented by CoCl<sub>2</sub>, 6H<sub>2</sub>O (2 parts per million) for 8 days at 28°C and tested according to the method of Cuthbertson and co-workers (1951), using a strain of *E. coli* mutant as the test organism.

Of the 80 strains tested for vitamin B<sub>12</sub> production, 48 showed positive activity. It was also found that there was apparently no relation between the production of antibiotics and that of vitamin B<sub>12</sub>. Tests were run simultaneously to check by means of paper chromatography, the production of methionine as a metabolite which was also known to give response to the growth of the test organism.

Of the isolates, strains belonging to *S. fradiae*, *S. californicus*, 8-80 group, characterised according to Gottlieb and Pridham (1948) were found to elaborate different amounts of vitamin B<sub>12</sub> under identical conditions of fermentation.

Further study on the choice of media and selective conditions of fermentation by the most potent strains is in progress, with the aim of investigating into the metabolic pathway of *Streptomyces* spp. specially in relation to the production of vitamin B<sub>12</sub> by means of tracer technique,



#### D.4. Studies on the production of an antifungal antibiotic by a *Streptomyces* sp.

Of the 29 strains found positive by the cup-plate assay method against *Curvularia* sp. and *Aspergillus niger*, one strain, Ac<sub>4</sub>(248), was selected for further investigations regarding isolation and partial purification of the antibiotic principle elaborated by it and its systematic identification.

Ac<sub>4</sub>(248), an unidentified strain of *Streptomyces* sp. was isolated from a soil sample collected from Darjeeling in November, 1953. A study of its morphological and physiological characteristics showed that the strain was related to *Streptomyces griseus*. The strain produced in modified straw infusion dextrose broth, an antibiotic substance which turned the beer highly active against a large number of fungi. The culture fluid had, however, no activity against any of the bacterial test organisms. As *Streptomyces griseus* also elaborates a highly antifungal antibiotic—actidione, a comparative study was made regarding the antifungal spectra of actidione (Res. No. 9207, the Upjohn Company, Michigan) and the culture liquid of Ac<sub>4</sub>(248) (Table IV).

The crude culture filtrate of Ac<sub>4</sub>(248) contained more than 100 dilution units of the antibiotic substance against *Curvularia* sp. when the organism was grown in stationary culture in modified straw-infusion dextrose broth at pH 7.4. The activity reached a maximum on the 8th day and remains unaltered for about 30 days. When subjected to a temperature of 100° C for 30 minutes, the culture filtrate lost half its activity.

From a comparative study by means of the bio-autographic technique, using n-butanol-acetic acid-water (4:1:1), water-saturated chloroform and n-butanol-chloroform (1:1), it appeared that the culture liquid of Ac<sub>4</sub>(248) might contain more than one antibiotic principle and that one of these might be identical with actidione produced by *Streptomyces griseus*. Further investigations to prove the identity of the substance by using actidione-resistant yeast strains have recently been undertaken.

Attempts made to isolate the antibiotic by liquid extraction using chloroform were partly successful. On evaporation of the solvent under vacuo, dark brown colored mass was obtained with activity ten times as great as the parent culture fluid. The active substance was found to be adsorbed by Norit's activated charcoal SBX 30 from the culture fluid at pH 7.0. A suitable eluant is still to be found. Various polar and nonpolar solvents were tried without much success.



TABLE IV.

COMPARISON OF ANTIFUNGAL SPECTRA OF ACTIDIONE AND CRUDE CULTURE  
FILTRATE OF AC<sub>4</sub>(248)

| Test fungi                            | Actidione | Ac <sub>4</sub> (248) |
|---------------------------------------|-----------|-----------------------|
| <i>Saccharomyces cerevisiae</i> .. .. | +         | +                     |
| <i>Curvularia specifera</i> .. ..     | —         | +                     |
| <i>Penicillium steckii</i> .. ..      | —         | +                     |
| <i>Helminthosporium oryzae</i> .. ..  | +         | +                     |
| <i>Penicillium notatum</i> .. ..      | +         | +                     |
| <i>Alternaria solani</i> .. ..        | —         | +                     |
| <i>Verticillium sp.</i> .. ..         | +         | —                     |
| <i>Fusarium sp.</i> .. ..             | +         | —                     |

#### D.5. Production of an antibiotic substance by a *Streptomyces* sp. active against gram-positive bacteria

A strain of *Streptomyces* sp. isolated from Dehra Dun forest soil was found to be antibiotically active against gram-positive bacteria on preliminary screening. The strain was grown in Czapek-Dox liquid culture media for 8 days at 28°-30°C and the culture filtrate was found to be active against *S. aureus*, *Enterococcus* and *B. subtilis* even at a dilution of 1 in 100 by agar cup method of assay. It was also observed that in course of fermentation, the beer attained a deep purplish colour at the end of the 8th day. The pigment was extracted by means of ether at a pH below 2.5 and after evaporation, a red pigment was left behind. This was dissolved in a minimum amount of alcohol at an acidic pH, re-extracted with ether and the whole operation was repeated till a red powder was obtained. The substance was found to be active against gram-positive bacteria.

The pigment was red in solutions of pH 3.0 or less, purple at pH near 7.0 and blue at pH near or above 9.0. The substance was soluble in water in the alkaline pH, 5% NaHCO<sub>3</sub> and NaOH.

Qualitative tests suggested the anthocyanin nature of the substance. On reduction with Zn dust in dil. acetic acid, the pigment became colorless. On aeration, the solution regained its colour.

On comparison with allied substances having antagonistic action, it was found to resemble litmanidin and litmanidin.



however, was reported to be elaborated by a *Proactinomyces* sp. The substance described by us differed from coelicolorin in certain respects especially in its behaviour towards alkali. No further confirmatory evidence could be given for the lack of comprehensive data in literature in the case of Litmocidin and Coelicolorin. Further study on the identity and properties of the substance is in progress.

#### **D.6. Further studies on the antibiotic substance produced by *Ac<sub>3</sub>*(203)**

The purified antibiotic gave no colouration with  $\text{FeCl}_3$ . It gave negative tests with 2-4-dinitro-phenyl hydrazine and Fehling's solution. The Elson-Morgan test was not responded. It was found to be strongly sensitive to ninhydrin reagent. The purified product was analysed as sulphate after drying *in vacuo* at  $60^\circ\text{C}$ . Found -C 27.2 H 6.21 N 6.9 Res 23.5. The infrared studies in cyclohexanol and Nujol indicated the polypeptide nature. The substance was hydrolysed with 6N HCl in a sealed tube for 36 hours at  $120^\circ\text{C}$  and the hydrolysate was analysed by means of both one-and two--dimensional paper chromatography using phenol-water and benzyl alcohol-acetic acid-water as developing solvents. Eight spots (one doubtful) were revealed on the chromatogram, the identity of which is now being studied. Further study on degradation products is in progress.

From a study of some of the microbiological and chemical properties of the substance it appeared that the substance might belong to neomycin complex. But it was also found that the ratio of activity against *E. coli* to that against *B. subtilis* was different from those described in literature. The substance did not induce resistance to *E. coli* even on 15 transfers.

To test the homogeneity of the substance as also for further purification of the product which still contains considerable amount of residual matter, it is now intended to operate the Counter-current distribution apparatus which has already been set up in this laboratory.

#### **D.7. Study on the effect of antibiotics and isonicotinic acid hydrazides on *Nocardia* (*Actinomyces*) *maduræ***

The above item of investigation has been communicated to the



#### **D.8. (a) The set-up of the apparatus for counter-current distribution**

The apparatus for counter-current distribution was designed after Craig's modified form. It consists of 24 single units made of Pyrex glass. The single units lie interlocked with the exit tube from one unit being inserted into the inlet tube of its neighbour. Each unit consists of an equilibration chamber, of which the volume of the lower part is made 10 cc after several trials. The system can be tilted by a mechanical arrangement and shaken to an angle of  $35^\circ$  on either side until equilibrium is attained so that neither of the phases of the solvents can splash out through the openings. After the phases have been allowed to separate, the unit is tilted to an angle somewhat more than  $90^\circ$ . The upper phase, 10 cc in volume, decants into the upper chamber, while the lower phase remains behind. When the unit is tilted back to the horizontal position, the upper phase in the upper chamber flows into the opening of the adjoining unit of the series. The units of the series are supported individually, the horizontal portion of each unit being attached to the wooden-frame with two brass clamps connected together by means of a tie-rod, while the vertical portion is fixed to its position by a third one. All clamps are movable and each unit can smoothly be held in its proper position. The rotation of the system is now done by means of a handle attached to the wooden frame. This will soon be replaced by an automatic mechanical arrangement.

#### **(b) Studies on the physico-chemical aspects of Counter-current distribution**

The instrument set up in the laboratory was standardised by a study of the distribution of methylene blue in two immiscible solvents—water and n-butanol. Prior to the standardisation the partition coefficient of methylene blue in the above system was found to rise constantly with dilution. The distribution of methylene blue in the solvents mentioned above, as studied in separating funnels by single withdrawal process, was found to obey the binomial expansion theorem, so far as the lower phase was concerned. Then the instrument itself was operated and the distribution in each unit was determined by means of spectro-photometer. It was observed that the resultant curve followed the binomial law within limits of error. So far as is known the counter-current distribution of the dye has not been studied elsewhere. It is proposed to study the



## E. ZOOLOGY

### E.1. Effect of penicillium on the metamorphosis of tadpoles

A few days after a heavy shower in the middle of June, 1953, some tadpoles of *Rana tigrina* were collected from different localities of Calcutta. Out of them 55 specimens were selected for experiments. They were placed in four glass vessels, each one containing ten of those selected specimens. The tadpoles of each vessel were treated differently with penicillin solution of different concentration. Fifteen of them were kept as control in a bigger jar containing fresh water. Out of these fifteen specimens eleven were transformed into froglets on different dates within a month or so, and four died shortly after starting the experiment. The result was quite different in the case of the treated specimens. Not a single one of them metamorphosed even after two months; but they were rapidly decreasing in number.

However, the surviving tadpoles were transferred to a bigger glass jar in the middle of August. By changing the water twice a week and putting in larger quantities of aquatic weeds their condition improved appreciably, and they looked more fresh and vigorous than before. In spite of that some more deaths occurred during the rest of the year.

On the February 18, 1954, altogether nine tadpoles were left in the experimental jar. Four of them were placed in separate vessels, each one containing 12.5 g of vitamin B<sub>12</sub> diluted in 300 cc. of water (1 µg in 24 cc). A considerable length of time elapsed but no change was observed in any one of the specimens. The other five were left in a big rectangular jar containing 3000 cc. of water to which 50 µg of vitamin B<sub>12</sub> (1 µg in 60 cc.) was added. By the 1st of March '54, it was observed that four of them had been transformed into froglets which came up to the surface of water for breathing. The remaining one metamorphosed four days later. But all of them lived for a short time.

The other four tadpoles, treated with higher concentration of vitamin B<sub>12</sub>, retained their larval stage. One of them died early in April, and the other three died on different dates by the end of April, '54.

Further experiments will be continued when fresh broods of tadpoles will be available during the next rains.

### E.2. Effects Antibiotics on metamorphosis of silkworms

Arrangements have been made for investigations on the effect of antibiotics on the metamorphosis of larvae of silkworm moths. After



the larva, by spinning fine threads of silk, begins to form its cocoon. When the cocoon formation is complete, the larva rests inside quietly and finally comes out as a winged moth. This is the last stage of its metamorphosis. Silkworms voraciously feed on mulberry leaves until maturity is reached when they stop eating and rest quietly. So, after 2nd or 3rd moult they may be fed with penicillin or other antibiotics along with the mulberry leaves, which can be impregnated with antibiotics by dipping the cut-ends of the stalks in the solution.

For this purpose two broods of eggs of multivolt silk-moth were collected and hatched. Leaves from mulberry trees planted in the Institute compound were supplied to them. Rapidly they were growing in length; but one day all of them disappeared suddenly. Probably they might have been devoured by the tiny pest-killing birds which abound in the Institute compound. Fresh broods of eggs were collected again and hatched. A number of larvae attained fairly big size over an inch in length, but their number gradually diminished during the middle of April, perhaps due to high temperature.

Rearing will be continued again by making some suitable arrangements for overcoming various difficulties.

#### F. LIBRARY

The Library consists of 3,387 volumes (1,671 books and 1,716 periodicals). During the year under report 159 volumes (54 books and 105 bound periodicals) were added to the stock as against 140 during the previous year. The total number of periodicals received was 93 (inland 15 and foreign 78), out of which 47 were purchased and the remaining 46 were received in exchange of Institute publications. The Library also received a large number of technical pamphlets, bulletins, circulars, reprints etc. from various Research Institutes and Government Departments, both inland and foreign.

The total number of volumes issued out of the Library was more than 2,500 and the volumes consulted in the Reading Room was near about 7,000.

In spite of the fact that the use of the Library is primarily meant for its research staff only, it is very frequently consulted by research workers and scientists from other institutions on account of its well-arranged selected acquisitions and efficient service. The number of such outside workers are increasing from year to year.

With the increase of research staff in the Institute and the growing number of outside research workers, there has been a pressing demand



funds it has not been always possible to meet their demands. It is now felt that further additions of a good number of important books and journals are extremely desirable to meet the requirements of the research staff as well as to build up an up-to-date Research Library.

### G. PUBLICATIONS

During the year under report the demand for Transactions (mostly on exchange basis) increased considerably. There has also been an appreciable increase in its sale. Many important and popular worker works Sir J. C. Bose viz. "Response in the living and Non-Living, "Plant Response" "Researches Irritability of plants", "Plant Autographs and their Revelations", etc. have been out of print for a long time.

"Plant Autographs and their Revelations" is expected to be published shortly and efforts are being made to reprint others in the near future. Others publications during the year under report include (1) Annual report 1952-53 and (2) The Fifteenth Acharya Jagadish Chandra Bose Memorial Lecture on "Role of Sand and Silt in the Economy of Multi-purpose River Valley Projects" by Dr. N. K. Bose With Director's Report. Volume 19 of the Transactions (1952-54) is now in press.

### H. WORKSHOP

The volume of work carried out in the Workshop is increasing rapidly. New constructional works, continuation of old works in connection with research and at the same time repair and maintainance of instruments and apparatus of the different departments were undertaken. The following is a list of some of the major works which were taken up and completed during the year.

1. Small ionization chambers (4 litres), one made of mild steel and two of brass, with their accessories.
2. Recording camera to record photographically the movement of the string of a Lindemann Electrometer.
3. One standard condenser.
4. Construction of a platform and assembly of a High Voltage-doubler circuit (150 kv), consisting of four condensers and two rectifiers.
5. Assembly of two stacks of condensers and rectifiers in a 8 stage



Work on the following apparatus commenced last year was also continued

1. The accessories of a H.P. cylindrical ionization chamber (40 litres)
2. Modifications of a rectangular cloud chamber and of its accessories
3. Assembly of the coils and E shaped pole pieces of the large electromagnet (10,000 G) on an iron structure including the 6" dia cylindrical cloud chamber.
4. The accessories of an Electrophoresis Apparatus
5. Six high intensity microscope lamps have been completed and are in use indifferent departments.

Besides general maintenance of gas, electricity, refrigerators and air-conditioning units, repair of fans, motors pumping sets etc. of the Institute, were also carried out. In the carpentary shop over and above the various types of work in connection with research and maintenance, some furniture were made for the Institute.



## APPENDIX

### I. The Governing Body :

Dr. Debendramohan Bose  
Mr. Sudhansumohan Bose  
Mr. Kedarnath Chatterjee  
Mr. Sudhir Kumar Mandal  
Mr. Abani Nath Mitter  
Mr. Satish Chandra Mukherjee I.C.S. (Retd.)  
Dr. Sisir Kumar Mitra  
Mr. Kshitish Chandra Neogi  
Mr. Bhupatimohan Sen I.E.S. (Retd.)

### II. The Council :

|                                     |                                       |
|-------------------------------------|---------------------------------------|
| Mr. S. M. Bose                      | } Nominees of the Govern-<br>ing Body |
| Mr. K. N. Chatterjee                |                                       |
| Mr. S. K. Mandal                    |                                       |
| Mr. A. N. Mitter                    |                                       |
| Dr. S. K. Mitra, D.Sc., F.N.I.      |                                       |
| Mr. S. C. Mukherjee, I.C.S. (Retd.) |                                       |
| Mr. B. M. Sen, I.E.S. (Retd.)       |                                       |

Dr. D. M. Bose, M.A., Ph.D., F.N.I. (*Ex-officio*)

Dr. S. S. Bhatnagar, D.Sc., F.R.S., F.N.I., Secretary to the Government of India, Ministry of Natural Resources and Scientific Research (Nominee of the Central Government)

Dr. S. R. Chatterjee, M.P. (Representative of the Parliament)

Dr. K. Krishnamurti, D.Sc.(Lond.), Principal, Science College, Nagpur

Dr. P. Parija, D.Sc., F.N.I., I.E.S. (Retd.) Pro-chancellor, Utkal University, Cuttack.

Mr. Nandadulal Sreemany (Representative of the Calcutta Corporation)

### III. Finance Committee :

Mr. B. M. Sen (*Chairman*) (representative of the Council)

Mr. K. C. Chaudhuri, Accountant General, West Bengal (representative of Central Government)

Dr. D. M. Bose (*Ex-officio*)

### IV. Building Committee :

Dr. D. M. Bose (*Ex-officio*)

Mr. K. N. Chatterjee (representative of the Council)



**V. Staff :**

*Director*—Dr. D. M. Bose, M.A., Ph.D., F.N.I.

*Registrar*—Mr. A. K. Ghosh, M.Sc.

*Special Officer*—Dr. J. P. Sircar, B.Sc.M.B., Ch.b (Edin.)

**Department of Physics :**

*Head of the Department*—Director.

*Research Scholar*—Mr. T. C. Bhadra, M.Sc., (Research Assistant from 1.1.54).

*Attached worker*—Prof. H. P. De, M.Sc., P.R.S. (Vidyasagar College, Calcutta).

„ Prof. S. P. Datta M.Sc. (Vidyasagar College, Calcutta).

**Department of Chemistry :**

*Head of the Department*—Dr. J. K. Chowdhury M.A., Ph.D., F.N.I. (*Special officer* from 1.5.53—15.1.54) ; Dr. P. K. Bose, D.Sc., F.N.I. (from 10.3.54)

*Research Fellow*—Dr. B. Banerjee, Dr. Phil. Nat.—on leave (died on 15.4.53).

Dr. A. Sen, M.Sc., Ph. D. (Leeds) (Also held charge of the Department from 16.1.54-9.3.54)

*Research Assistant*—Dr. D. P. Burma, M.Sc., D. Phil. (Research Fellow from 1.11.53)

*Birla Scholar*—Dr. G. V. Ramakrishnan, M.Sc., Ph.D., (upto 31-5-53).

*Government of India Senior Scholar*—Mr. R. K. Basu, M.Sc.,

„ „ „ „ *Junior* „ Mr. C. R. Raha, M.Sc.,

„ „ „ „ Mr. A. K. Guha, M.Sc.

*Attached worker*—Mr. N. N. Banerjee (Textile Institute, Serampore).

„ „ Dr. S. N. De, M.B., D.T.M., Ph.D., (Lond.) (Nilratan Sircar Medical College, Calcutta).

**Department of Botany :**

*Head of the Department*—Dr. K. T. Jacob, M.A., Ph.D. (Lond.)

*Research Fellow*—Dr. S. K. Roy, M.Sc., Ph.D. (Lond.), D.I.C.

*Research Assistant*—Mr. B. K. Palit, B.Sc.,

„ Mr. B. K. Datta, B.Sc.

„ Mr. A. T. Guha Thakurta

*Research Scholar*—Mr. S. B. Sarkar M. Sc (upto 31.7.53)



*Government of India Junior Scholar*—Mr. Samir Kar, M.Sc. (Ag.)  
upto 22.4.53)

Mr. Smritimoy Bose, M.Sc.

Mr. V. N. Gadgil, M.Sc.  
(on deputation from Nagpur  
University) upto 31.10.53.

*Attached worker*—Mr. D. K. Chakraborty M.Sc. (R. G. Kar  
Medical College, Calcutta)

Miss Madhuri Datta, M.Sc. (Lady Brabourne  
College, Calcutta)

### Department of Microbiology :

*Research Fellow*—Dr. P. N. Nandi, M. Sc., Ph.D. (Lond.), D.I.C.  
(In-charge of the Department)

*Mary and Richard Keating Student designate*—Mr. S. P. Sen (on  
study abroad)

*Sir J. C. Bose Scholar*—Mr. G. P. Sen, M.Sc. (upto 2.12.53)

Mr. Ajit Kumar Banerjee, M.Sc.

*Government of India Junior Scholar*—Sri Ajit Kumar Mishra, M.Sc.  
(from 2.2.54)

*Attached worker*—Mr. S. K. Mukherjee, M.Sc. (Surendranath  
College, Calcutta)

### Department of Physiology :

Mr. G. C. Bhattacharya

### STAFF APPOINTED UNDER GRANT-IN-AID SCHEMES

#### A. Board of Research on Atomic Energy (India)

(Investigator-in-Charge—Dr. D. M. Bose)

(i) Cosmic Ray Investigations:

Dr. S. D. Chatterjee, D.Sc. (*Honorary*)

Dr. M. S. Sinha D.Sc.

Mr. I. L. Chakraborty, M. Sc.

Mr. N. C. Das, M.Sc.

Mr. N. N. Biswas, M.Sc.

(ii) Nuclear Physics Investigations:

Mr. A. M. Ghosh, M.Sc.

Mr. N. K. Ganguly, M.Sc.

(iii) Neutron Generator:

Mr. A. N. Banerjee, M.Sc.,

Mr. H. N. Raha

(iv) Use of  $C^{14}$  and  $P^{32}$  as tracers in photosynthetic and  
plant genetic investigations



**B. Indian Central Jute Committee**

- (i) Impregnation of Bleached jute yarns with suitable synthetic resins—(Investigator-in-Charge—Dr. J. K. Chowdhury)  
Mr. R. P. Chatterjee, M. Sc. (upto 10.2.54)  
Mr. A. C. Ghosh, M.Sc.
- (ii) Production of suitable mutants in Jute by X-ray irradiation—(Investigator-in-Charge—Dr. D. M. Bose and Dr. K. T. Jacob)  
Mr. R. K. Basu, M.Sc.  
Mr. B. C. Mukherjee, M.Sc.

**C. Indian Central Oilseeds Committee**

- Inducing mutants with economic characters in til, rape & mustard by X-ray (Investigator-in-Charge—Dr. K. T. Jacob)  
Mr. K. L. Chowdhury, M.Sc.  
Mr. Ashok Das, M.Sc.

**D. Government of West Bengal (Directorate of Agriculture)**

- Breeding of long Stapled Cotton in West Bengal (Investigator-in-Charge—Dr. K. T. Jacob)  
Mr. A. K. Adhikari, M.Sc. (*Also in Charge of the Farm at Falta*)

**E. Sir J. C. Bose Research Fellow—Calcutta University (Investigator-in-Charge—Dr. D. M. Bose)**

Mrs. Mridula Datta, M.A.

**F. Indian Council of Agricultural Research**

- Control of Weeds (Investigator-in-Charge—Dr. K. T. Jacob)  
Mr. K. George, M.Sc.  
Mr. M. G. Shrivastava, M.Sc.

**G. Imperial Chemical Industries (India) Ltd. Fellow**

- National Institute of Sciences of India (Investigator-in-Charge—Dr. D. M. Bose)  
Dr. A. Ganguly, B.Sc., Ph.D. (Edin.)

**H. Council of Scientific and Industrial Research:**

- Studies on the Production of antibiotic substances by *Streptomyces* spp. (Investigator-in-Charge—Dr. P. Nandi)  
Mr. G. P. Sen, M.Sc. (from 3.12.53)  
Mr. S. B. Ghosh, M.Sc. (from 3.12.53)

**I. Burma Oil Company :**

- Paleobotanical Research (Investigator-in-Charge—Mr. A. K. Ghosh)