

REPORT
OF
THE BOSE INSTITUTE
FOR
1956-57

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BOSE INSTITUTE

93/1 UPPER CIRCULAR ROAD, CALCUTTA-9

CONTENTS

	PAGE
1. GENERAL	1
2. RESEARCH ACTIVITIES (ABSTRACT)	7
3. REPORTS :	
A) Physics	
1) Ultrasonics	11
2) Cosmic Ray	11
3) Nuclear Physics	14
4) Neutron Generator	15
5) Ionising Radiation effects	16
B) Chemistry	
1) Physical & Biochemistry	18
2) Plant Chemistry	20
3) On the nature of the irritability substances present in <i>Mimosa pudica</i> Linn.	26
4) Radio-chemistry	27
C) Botany	
1) Plant Biochemistry	30
2) Plant Physiology	37
3) Cytology (i)	40
4) Radiation & Cytogenetics	44
5) Radiation Cytology	119
6) Cytology (ii)	123
7) Anatomical studies	126
8) Weed Control	129
D) Microbiology	
1) Production of antibiotics by soil micro-organism	135
2) Studies on the physiology of <i>P. Vermiculatum</i> Dangeard	138
3) Studies on the induced mutation in micro-organism	141
4) Industrial Fermentation	142
5) Studies on counter-current distribution	143
E) Zoology	
1) Precocious metamorphosis etc.	145
2) Action of thiourea & penicillin on the tadpoles of <i>Rana tigrina</i>	146
3) The effect of thiourea on the phosphatase contents of thyroid gland of rats	147
Workshop	148
Library	149
Appendix (Staff) <i>Gm</i>	151

REPORT OF THE BOSE INSTITUTE

1956-57

Governing Body. Two meetings of the Governing Body were held during the year in course of which the Regulations and Bylaws governing its activities were revised.

One senior member of the Governing Body, Sri K. C. Neogy, Member, Planning Commission, had sent a letter of resignation on account of his continued absence from Calcutta. The Governing Body at its meeting held on December 1, 1956 accepted his resignation with great regret, after recording their appreciation of his valuable services to the Bose Institute.

Dr. B. D. Nag Choudhuri, Palit Professor of Physics, Calcutta University, has been elected a member of the Governing Body.

Council. Five meetings of the Council were held during the year. Based upon the recommendations of a Committee appointed for the purpose, the Council at the meeting held in July 1956, revised its existing Regulations and Bylaws. These along with proposals for revision of scale of pay of some of its staff members are with the Government of India since July 1956 for its consideration and approval.

The Government of India has intimated the sanction of the following development grants for the Second Five Year Plan period : Rs. 25.00 lakhs for recurring and Rs. 12.5 lakhs for non-recurring expenditure.

Grants. The following grants were received during the year 1956-57 :

(a) *Non-recurring grants* (i) Rs. 2.00 lakhs from the Government of India which was allocated as follows:

Building	Rs. 70,000/-
Apparatus	92,000/-
Cold Room	2,000/-
Dark Room	2,000/-
Workshop	32,000/-
Furniture & Fittings	2,000/-

Rs. 2,00,000/-

(ii) Rs. 30,000/- contributed in half the amount each by the Indian Central Jute Committee and the Indian Central Oilseeds Committee for the construction of a 20-curie Cobalt 60 field at experimental Farm of the J.A.R.I. at Nilgunge.

(iii) Rs. 20,000/- from the Atomic Energy Department, Govt. of India for cosmic ray measurement to be undertaken during the International Geophysical Year 1957-58.

(b) *Recurring Grants*

Government of India	Rs. 4,00,000/-
-do- for training in scientific research	12,666/5/-
Governing Body, Bose Institute	45,685/-

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(c) *Grants-in-aid schemes*

The following grants-in-aid were received during the year :

<i>Schemes</i>	<i>Sponsoring Body</i>	<i>Amount of grant</i> Rs.
X-ray irradiation on oilseeds	Indian Central Oilseeds Committee	30,630/-
Weed Control	Indian Council of Agricultural Research	14,100/-
Antibiotic Production	Council of Scientific and Industrial Research	11,351/-
Jute scheme	Indian Central Jute Committee	15,471/8-*
Cosmic ray investigation	Board of Research on Atomic Energy	1,00,000/-
Nuclear Physics investigation		
Neutron Generator investigation		
Induced mutagenesis in crop plants using x-rays and radioactive isotopes		
For Research scholarship and stipend and foreign scholarships	Sir J. C. Bose Trust Fund No. 1	14,000/-

*Amount received after 31st March 1957.

Acharya Jagadish Chandra Bose Memorial Lecture.

The Eighteenth Lecture of the series entitled, "Frontiers of Biology" was delivered by Dr. A. C. Ukil, M.B., M.S.P.E., F.S.M.F.B., F.N.I., President, National Institute of Science of India, on Friday, November 30, 1956. The lecture has been published along with the Director's report presented to the 39th Anniversary meeting of the Institute.

Study Abroad.

1. Dr. P. Nandi, Reader in Microbiology was awarded Colombo Plan Training Fellowship to avail himself of the training facilities at the Biological laboratories of the Atomic Energy of Canada Ltd., at Chalk River for eight months. He spent the rest of his study leave visiting different laboratories in the U.S.A., the U.K., France and Italy.

2. Sri K. L. Chaudhuri, Botanist in an Oilseed Scheme has been awarded a Research Fellowship by the Danish Foundation in Denmark for one year. He has joined the Genetisk Institut, Copenhagen for investigation on chemically induced mutations.

3. The study leave of Dr. D. P. Burma was extended upto 9-8-57 to enable him to complete his research programme.

Grants for study abroad.

A grant of Rs. 2000/- out of Sir J. C. Bose Trust Fund was made available to Sri K. L. Chaudhuri to defray the cost of passage to Denmark.

A similar grant of Rs. 2000/- was made available to Dr. P. Nandi in London to undertake a study tour visiting various laboratories in U.K., Paris and Rome, on his way back from Canada after completion of his training under Colombo Plan.

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Visitors.

The following visited the Institute during 1956-57 :

- (1) Prof. J. B. S. Haldane, F.R.S. and Dr. Helen Spurway, (2) Prof. Avenasyan, Counsellor, Russian Embassy, (3) Dr. David E. Goldman, Scientific Liaison Officer, Embassy of U.S.A. in London who also delivered a lecture, (4) Shri R. S. Randhawa, I.C.S., Vice President, I.C.A.R., (5) Dr. B. P. Pal, Director, Indian Agricultural Research Institute, (6) Pt. K. N. Agha, Secretary, Indian Central Jute Committee, (7) Dr. Ralph, J. Strom, A.E.C., U.S.A., (8) Dr. R. S. Krishnan, Indian Institute of Science, Bangalore, (9) Dr. John F. Hogerton, Project Manager, Vitro Engineering Division, New York, (10) Dr. Q. I. Kalamkar, Add. Agri. Commissioner, New Delhi, (11) Dr. F. C. Von de Tage, Oak Ridge National Laboratories, U.S.A., (12) Prof. Masao Watanabe, International Christian University, Tokyo, Japan, (13) Dr. B. N. Lal, Dy. Director of Agriculture, Lucknow, (14) Dr. Huang Chi Fong, South China Agriculture Research Institute, Canton, China, (15) Dr. Chao Hung Chong, North Western Agricultural College, China, (16) Prof. Shizuo Hattori, University of Tokyo, Japan, (17) Dr. S. Hussain Zahir, Director, Regional Research Laboratories, Hyderabad, (18) Prof. Chang Chao-Chin, South China Bot. Inst., Canton, (19) Dr. Pan Shiao Thin, Inst. of Applied Physics, Peking, (20) Dr. D. S. Kothari, (21) Prof. Harold B. Tukey, Prof. of Horticulture, Michigan State University, (22) Mr. William Alvarez, Administrative Officer, I.C.A., (23) Madam M. Lecomte du Nouy, (24) A group of Russian Scientists including Atomic Physicist.

During the 44th Session of the Indian Science Congress Association a large number of delegates, both Indian and foreign, visited the Institute which included amongst others the following :

- (1) Dr. David E. Green, (2) Prof. L. Marton, (3) Prof. V. Gordon Childe, F.R.S., (4) Sir Harold Spencer Jones, F.R.S., (5) Dr. G. Herzberg, F.R.S.

New Appointments and Awards.

1) Dr. Sunanda Bose, now on study abroad, is awarded a Govt. of India National Research Fellowship.

2) Dr. A. K. Barua was awarded a Govt. of India National Research Fellowship with effect from 1-6-56.

3) Sm. Nilima Basu, Junior Research Assistant in A.E.C. scheme was awarded an A.E.C. Junior Research Fellowship with effect from 1-4-56.

4) Mrs. Mridula Dutta, Mary and Richard Keating Student was awarded an I.C.I. Fellowship of National Institute of Science of India, with effect from 10-9-56.

5) Sm. Chitra Ghosh was awarded Mary and Richard Keating studentship *vice* Mrs. M. Datta, with effect from 22-9-56.

6) Sri U. K. Rai, Asst. Botanist in Oilseeds scheme was appointed Botanist in the same scheme *vice* Sri K. L. Chaudhuri on study leave, with effect from 1-5-56.

7) Sri Ramendra Nath Mookherjee was appointed Asst. Botanist *vice* Sri U. K. Rai promoted with effect from 1-5-56.

8) Sri R. K. Basu, Junior Research Assistant in A.E.C. scheme was appointed Cytologist in the scheme entitled "Radiation Mutation in Jute" aided by Indian Central Jute Committee, with effect from 16-5-56.

9) Sri Arun Kumar Raichowdhury was appointed Statistician with effect from 16-2-57.

10) Dr. S. K. Roy, Research Fellow, was appointed as Actg. Registrar with effect from 1-1-57 *vice* Sri A. K. Ghosh granted leave.

11) Sri Patit Paban Mookherjee was appointed Junior Research Assistant in the Scheme entitled 'Production of antibiotics by *Streptomyces* spp.' sponsored by the C.S.I.R. with effect from 8-5-46, *vice* Sri G. P. Sen, Senior Research Assistant resigned.

12) Sri Amal Kumar Bose was appointed Junior Research Assistant in A.E.C. scheme, with effect from 16-5-56 *vice* Sri R. K. Basu transferred to Jute scheme.

13) Sri Chittaranjan Mallik, was appointed Junior Research Assistant in the A.E.C. scheme with effect from 11-2-57 *vice* Sri N. C. Das resigned.

14) Sri Sailendra Nath Sen Gupta was appointed Junior Research Assistant in the A.E.C. scheme with effect from 2-8-56 *vice* Sm. N. Basu awarded A.E.C. Junior Research Fellowship.

15) Sri S. Pattabi Raman was appointed Research Scholar in the Department of Chemistry with effect from 24-7-56.

16) Sri A. K. Mishra, Junior Manpower Scholar, Govt. of India, was appointed Research Scholar in the Department of Microbiology with effect from 1-8-56.

17) Sri S. R. Ghosh was appointed Superintendent in charge of Refrigeration, Electricals and Electronics with effect from 1-4-56.

18) Sri A. K. Medda was appointed Senior Manpower Scholar with effect from 1-6-56 *vice* Sri U. K. Rai resigned.

19) Sri B. B. Biswas, Junior Research Asstt. in the A.E.C. scheme was awarded a Research Scholarship in the Dept. of Botany with effect from 1-12-56.

20) Sri A. P. Mani was appointed Research Assistant in the I.C.A.R. Weed Control scheme with effect from 14-9-56 *vice* Sri K. George resigned.

21) Sri V. S. Sharma was appointed Research Scholar in the Dept. of Botany with effect from 1-4-56.

Resignations.

1) Sri Ranendra Nath Chakraborty, Research Scholar in the Dept. of Chemistry, resigned with effect from 11-8-56.

2) Sri A. K. Banerji, Sir J. C. Bose Research Scholar in the Dept. of Microbiology was released from 1-7-56 to enable him to take up the post of Asstt. Microbiologist at the Jute Agricultural Research Institute, Barrackpore.

3) Sri Asoke Das Gupta, Birla Scholar, in the Dept of Microbiology was released from 1-12-56 to enable him to join in a permanent service of the Govt. of West Bengal.

4) Sri K. George, Asstt. Botanist, I.C.A.R. Weed Control Scheme resigned with effect from 4-7-56.

5) Sri N. C. Das and Sri A. N. Banerjee, Junior Research Assistants in the A.E.C. scheme resigned their appointments with effect from 15-9-56 and 15-12-56 respectively to join the Physics Department of the Jadavpur University.

Grant-in-aid schemes.

In addition to the existing grant-in-aid schemes the following new grant-in-aid schemes were received :

1) Scheme entitled, "Radiation Mutation on Jute" aided by Indian Central Jute Committee.

2) Scheme entitled, "Investigation on the induced mutagenesis in crop plants using X-rays and radioactive Isotopes" sponsored by the Dept. of Atomic Energy.

Termination of scheme.

The scheme entitled, "Use of C^{14} & P^{32} as tracers in photosynthetic and plant genetic investigation" aided by the Dept. of Atomic Energy, Govt. of India, terminated with effect from 30-11-56.

Degree awarded.

1) Dr. Sunanda Bose now on study abroad has been awarded the degree of Filosofic Licenciat of the University of Lund.

2) Dr. Satyabrata Sarkar, has been awarded the degree of Dr. rer. Nat. of the University of Tübingen, West Germany.

3) Sri K. George has been awarded D.Phil degree of the Calcutta University.

Seminar.

Fortnightly seminars were held during the period under review, when members of the research staff reported on the results of their investigations and reviewed the progress of work done on selected topics. This helps the dissemination of scientific knowledge among the members of the research staff dealing with different subjects.

<i>Date</i>	<i>Speaker</i>	<i>Subject</i>
4-4-56	Sri K. L. Chaudhury	X-ray studies on sesamum and Mustard.
17-4-56	Sri A. K. Mishra	Ultraviolet induced mutations in <i>Aspergillus niger</i> .
1-5-56	Sri A. K. Banerjee	Chemistry of...
16-5-56	Dr. A. K. Barua	Use of Boron Trifluoride as catalyst in organic reaction.
6-6-56	Sri Asoke Das Gupta	Physiology of sexual reproduction in <i>Penicillium Vermiculatum</i> .
26-6-56	J. Datta	Polarography.
10-7-56	Sri A. M. Ghosh	The Neutrino.
31-7-56	Sri U. K. Rai	Inheritance of flower and seed color in Sesamum and Mustard.
30-8-56	Sri S. K. Chakraborty	Physiological properties by Flavonoid pigments.

<i>Date</i>	<i>Speaker</i>	<i>Subject</i>
8-9-56	Sri B. B. Biswas	Nucleic Acid in Blue green Algae.
14-12-56	Dr. S. P. Sen	Carbon dioxide fixation and plant metabolism.
25-2-57	Dr. M. S. Sinha	Cascade decay of heavy K-mesons.

Special Lecture and Seminar.

a) A group of distinguished American scientist from Brookhaven National Laboratory, U.S.A., came to Calcutta to discuss the proposed Asian Regional Nuclear Centre to be established in the Philippines, and a seminar was arranged on 30th April 1956 in the Lecture Hall of the Institute. A large number of distinguished scientists of Calcutta were also present.

b) Under the joint auspices of the Bose Institute and the Indian Science News Association Prof. J. B. S. Haldane, F.R.S., delivered an address on "Time in Biology" on 20-9-56.

c) Dr. David E. Goldman, Scientific Liaison Officer, Embassy of U.S.A., London, gave a talk entitled, "The effect of Ultrasound on living cells".

d) Under the auspices of the National Institute of Science of India a Symposium on "Scientific Research in relation to National Development" and a lecture on Atomic Fall-out entitled, "On some aspect of Nuclear Explosion" by Professor D. S. Kothari were held in the Lecture Hall of the Bose Institute.

e) The following special lectures were also delivered by Indian and foreign scientists during the 43rd Session of the Indian Science Congress.

(i) "An introduction to the Biochemical Machinery of Cell" by Professor D. E. Green.

(ii) "Prehistoric culture zones in Upper Eurasia with reference to the Aryan migration" by Professor V. Gordon Childe.

(iii) "Electron scattering phenomena" by Professor L. Marton.

(iv) "Rupkund expedition" by Dr. N. Dutta Mozumder.

(v) A symposium on "Induction of mutant by physical and chemical methods" was also held.

New building construction and laboratory extensions.

On the western end of the Institute grounds after the clearance of the green house and the single storied lower subordinate staff quarters, constructions of a two storied block, each of floor area 3500 sq. ft. housing the workshop, and of a three storied block each story containing 8 rooms to accommodate the junior subordinate staff, are nearing completion.

The masonry work and the flooring of the laboratory building are complete; plumbing, electrical wiring, furnishing with tables cupboards etc., have been taken in hand.

Shamnagar Station. A 3 tube well has been sunk from which water is raised by means of a pump and diesel engine. The water raised is to be utilized, partly for irrigation and partly for supplying to the laboratory.

The chemical laboratory extension as well as the two low temperature air-conditioned rooms have been put into regular use.

Plans for the erection of a three acre gamma radiation field at the Jute Agriculture Research Institute at Nilgung have been completed. A 20 curie Co-60 gamma radiation source has been obtained from Norway. It is now found that due to all round increase in prices the total cost of erection and equipment will exceed the amount of Rs. 30,000/-, contributed jointly by Indian Central Jute Committee and Central Oilseeds Committee. Application for additional grant has already been made.

RESEARCH ACTIVITIES

Cosmic Ray investigation. The Institute is cooperating in the Cosmic Ray programme of the International Geophysical Year which officially begins on July 1, 1957. Two hard meson cubical telescopes have been set up at Mayapuri Darjeeling. Two sets of neutron monitoring equipments, one using three enriched BF_3 proportional counters imported from the USA, and the others to be made in the Institute and filled with enriched BF_3 , are being assembled.

A large pressure ionisation chamber, made a few years ago for continuous cosmic ray investigations is being reconditioned for measurements in Calcutta.

Very interesting results have been obtained on the production in absorbers, of intermediate charged and uncharged particles, of mass some larger than proton and others between that of proton and pion, and of their disintegration products.

Nuclear Physics. An arrangement has been devised in the Institute which enables the determination of the absorption cross section for thermal neutrons in absolute units. Using neutrons of even lower temperatures, the scattering by bound protons can be observed which gives information on the nature of the hydroxyl bond in water and in several acid molecules.

The construction of an apparatus for radioactive carbon dating is proceeding.

Radiation damage studies. The Institute is now handling increasing quantities of radioactive materials. It is proposed to arrange for the appointment, out of grant-in-aid funds, of a whole time officer for monitoring the laboratories and radiation fields for stray radiation.

A problem intimately related to the above is the study of radiation damage. The study of metabolic changes produced in pure strains of albino rats exposed to gamma radiation, has been taken up this year.

Physical Chemistry. The Tiselius Electrophoresis apparatus is now being employed for (a) isolation and characterisation of seed proteins of Sesamum and Mustard and (b) in the analysis of sera of allergic patients for comparison with that of normal persons. A gas chromatographic apparatus is being assembled.

Plant Chemistry. Antimicrobial activities of some plants products are being studied. A survey of the saponin bearing plants of this country is being undertaken; the alkaloidal possibilities of local flora, including those of the non-medicinal plants has been continued.

The constituents of some of the Indian species are being determined. The constitution of triterpene acids and other constituents of certain plants like *Pistacia integerrima*, *Ficus* etc., are being continued.

Further studies have been made on the constitution as well as the distribution of the irritability substances in the group of plants with motile, semimotile and non-motile pulvini as classified by J. C. Bose. It was observed that in the sap exuded after stimulation from the most sensitive plant, *Mimosa pudica*, contained principally glycine, alanine, and glutamic acid. A seasonal variation in the composition of the sap was observed *viz.*, during the winter months the glutamic acid disappeared. In the sap obtained from less sensitive plants *Mimosa spegazzini* or *Averrhoa carambola* either only two amino acids or none were detected. The work is proceeding.

Radio chemistry. Compounds tagged with radioactive Sulphur-35, Carbon-14, are being employed for the purpose of study of carbon fixation and metabolism in plants. Amongst the problems which are being studied are : (i) sulphur metabolism in plants, (ii) role of thioctic acid in photosynthetic fixation of CO_2 , (iii) carbohydrate fixation in relation to auxin induced growth and inhibition, (iv) CO_2 fixation and photoperiodism etc.

Plant Physiology. *Mimosa problem.*—In the last report attention was drawn to the occurrence of spontaneous random fall of the *Mimosa* leaflets, even when the plants were kept under constant condition of light, temperature and humidity. Alternative explanation suggested in last year's report that such spontaneous leaf fall was due to impact of cosmic radiation was found to be not tenable. Such spontaneous leaflet falls are found to disappear during winter and hot summer months, and also in branches separated from the plant. A new series of investigations suggest that such falls are caused by the flow of plant hormones from the growing stem to the young leaf systems of a *Mimosa* plant, especially during the rains. These investigations are being continued.

The diurnal movement of the *Mimosa* leaflet with the spontaneous evening fall has been studied with a modification of J. C. Bose's plant sphygmograph which enables the recording of the change of volume of the pulvinus accompanying the leaf fall. It was found that the diurnal record of the changes of the volume pulvinus to be a replica of the diurnal record of the petiolar movements. This observation makes untenable Pfeiffer's explanation that the evening fall is brought about by the increased mechanical moment of the sub- petiole.

Gall tumor.—Plant gall tumors are usually produced by injecting into certain susceptible host plant tissue the bacteria *Agrobacterium tumefaciens*. After gall tumor has been produced the next problem is to get rid from the tumor the infecting bacteria and to continue growing the tumor tissue in synthetic culture media. In the Bose Institute the procedure adopted has been to introduce into the culture medium some antibiotic substances like penicillin, streptomycin, actinomycin, pyocyanin. Out of these, treatment with streptomycin gave the best results. So far bacteria-free culture of tumor tissue of Hollyhocks has been grown satisfactorily for 16 months. In addition bacteria-free Bryophyllum gall tissue has been successfully cultured. Attempts are being made by varying the

synthetic culture medium to obtain similar cultures for Tropaeolum, Balsam and Marigold. Comparative studies of respiration, phosphorus metabolism, and of the polysaccharides obtained from normal and gall tissues of some of the plants are being carried out.

Studies on certain aspects of metabolism of Blue green alga *Nostoc muscorum* have been undertaken during the year; utilisation of different C^{14} labelled compounds for nucleic acid and polysaccharide syntheses, and of phycocyanin synthesis in relation to nucleic acids, are being investigated.

The study of the relative distribution of the mitochondrial respiratory activity in roots and stems of mung and maize, as two typical representatives of dicot and monocot families, have been taken up; for this purpose different respiratory substrates like succinate, malate and citrate are being used.

The phosphorus metabolism of higher plants using radioactive isotopes P^{32} as tracer has been undertaken. The effect of an inhibitor like fluoride in the incorporation of P^{32} in phosphointermediates has been studied. It appears that such compound suppresses utilisation of glycolytic breakdown along Kreb's tricarboxylic acid cycle, and results in the diversion of glucose breakdown more towards the pentose phosphate pathway. The problem is being further investigated by the use of specific inhibitors, like iodoacetate of triosephosphate dehydrogenase. At the time of the writing of the report preliminary studies of the radioautographs show a distribution more or less similar to that obtained with fluoride.

Radiation genetics. The mutagenic action of radiation on seeds of economic plants have been undertaken in the Institute for several years. The sources of radiation employed are x-rays, β -radiation from the isotopes S^{35} and P^{32} . The plants which have been investigated are :

(i) *Oilseeds like Sesamum and Brassica.*—Here the progenies obtained from radiated seeds can give rise to mutants with recognizable morphological characters like the white flowered and small seeded mutants obtained from irradiated *Sesamum* type 16. In other cases, there are no noticeable morphological characters, but in certain cases there are increases, as compared to those in controls, in the number of fruits per plant, in the weight of say, 1000 seeds, increase in the oil content of seeds and keeping quality of the oil.

In the case of mustard, the progenies from irradiated seeds have not produced any recognizable morphological mutants, but certain progenies are characterized by better keeping quality and nutritive value of the oil obtained from progenies of irradiated seeds, In other cases there was higher yield, and earlier flowering compared to the control.

The irradiation investigations were started later with Mustard as compared to those with *Sesamum*. The progenies are still in the stage of selection and stabilization.

(ii) *Jute.* Last year the production by treatment with P^{32} of two dominant mutants, one like the Tall Mutant and the other like Chinsurah Green, by treatment of R-26, was reported. The segregation of characters in the succeeding generations of progenies is being followed up.

This year varietal trials with three varieties of Olitorious jute, Chinsurah Green, R-26, and Tall Mutant (the latter an X-ray mutant in the 10th generation) have been continued. The characters statistically studied are yield of fibre, the weight of green plants, and the yield of wood. In each case the best yields were obtained with T.M. followed by C. G. and R-26.

(iii) *Paddy*. Here the best results were obtained from treatment of Patnai, a variety of aman paddy with S-35. A red husked and a small seeded variants were obtained. The former segregated into plants with deep red and light red husks, both of which were with or without awns and the tillers were either red or green. The small seeded variant segregated into small seeded and normal seeded grains which were with or without awns. The dark brown colour of the husk obtained from S₁ population of *Bhasamanik*, another variety of aman paddy, has been found to breed true.

Weed Control. The environmental conditions in which the application of weedicide gives best results, as well as the residual effects of herbicidal chemicals in the soil have been studied. It has also been noticed that the drift effect of chemicals through water, remains perceptible upto 1½ ft. from place of application. The air drift of chemicals is not very serious.

Microbiology. Systematic surveys of actinomycetes occurring in Kashmir soil, and of antibiotic producing soil bacteria have been undertaken. A ten litre fermentor for pilot plant production of antibiotic substances has been set up. Further studies on the technique and application of counter current distribution has been continued.

Nutritional mutants in *Aspergillus niger* var *Tieghem* is being further studied. Investigations on Ultraviolet light induced mutation in a *Streptomyces* sp. A₁₂ has been taken up.

The Head of the Department, Dr. P. Nandi was on a study tour for eight months in Europe and North America. During this period he studied several new research problems which will be taken up by the department during the following year.

Delayed metamorphosis of tadpoles. The investigations on the retarded metamorphosis of tadpoles of *R. tigrina* under penicillin treatment and its termination under treatment with B₁₂ or Thyroxine are being continued. The question whether antibiotics like penicillin has any direct action on the thyroid glands or its action is mediated through the retardation of growth of B₁₂ secreting micro organisms present in the intestine flora of the tadpole is being continued. It has been found that thio-urea has similar metamorphosis retarding effect on tadpoles. The nature of the action of thiourea on the thyroid glands is being further studied by treatment of albino rats with the compound and examining the nature of enzyme changes produced in the thyroid gland. It was noticed that both alkaline and acid phosphatase in the thyroid glands of the treated rats were greatly reduced in comparison with those in the control animals.

A. PHYSICS

A. 1. Ultrasonics

A.1.1. Construction of an acoustic Interferometer for investigating the intensity distribution in the successive order of diffraction pattern produced in a source of monochromatic light through a liquid medium traversed by ultrasonic radiation.

The main components of the apparatus are:

(i) a Hg. resp. Na. vapour lamps, (ii) Rotating sectors, (iii) Thermostatic bath whose temperature can be kept steady by means of a Sunvic relay and toluene thermo regulator, (iv) Photocell for measurement of light intensity, (v) Crystal transducer unit mount by means of which stationary ultrasonic wave can be produced in a given liquid between a fixed metallic plate reflector and the transducer which can be adjusted by various micrometer screw arrangements.

A.1.2. Investigations carried out during the past two years relating to the generation of ultrasonic waves, the absorption of the radiations in the liquid media, and its relation to the streaming produced in the latter, have been incorporated in a D.Phil. thesis.

As an introduction to the thesis the present state of our theoretical knowledge of the hydrodynamics of the propagation and absorption of elastic waves in liquid media has been discussed and also of the additional assumption which have to be made to explain anomalous absorption in certain liquids and to the account for the streaming which accompanies the propagation of ultrasonic radiation in an absorbing liquid media.

Further investigations on the relation between sound absorption and hydrodynamic streaming in strongly absorbing liquids like carbon tetrachloride, benzene, and ethyl alcohol by the cavity radiometric method, are being carried out.

A. 2. Cosmic Ray

A.2.1. High Altitude studies

The big square cloud chamber has been running smoothly at Darjeeling with a penetrating shower trigger. The pictures obtained in the previous year have been fully analysed and interesting results have been obtained for the nuclear diameters of Al, Cu and Pb atoms from cosmic ray interactions in these materials. The total number of nuclear interactions observed were divided into two groups, (i) nuclear disintegrations (high energy transfers) and (ii) nuclear scatterings (elastic); the *total* cross section and the cross section for nuclear disintegrations alone were determined. It is found that the equivalent square well radii of Al, Cu, and Pb nuclei found from the latter cross sections agree well with the equation $R_0 = 1.19 \times A^{\frac{1}{3}} \times 10^{-13}$ cm, where A is the mass number of the material. This indicates the same matter distribution in Al, Cu and Pb nuclei as that determined from high energy electron scattering, μ -mesonic X-ray data and high energy neutron absorption data. But the radii corresponding to the total cross sections follow the equation

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$R_N = 1.34 \times A^{\frac{1}{3}} \times 10^{-13}$ cm. Thus each nucleus appears to be surrounded by an equivalent spherical shell of thickness $0.15 \times A^{\frac{1}{3}} \times 10^{-13}$ cm, which is chiefly responsible for the nuclear scatterings.

A number of decay events have been obtained, the majority of which have been identified with the Λ^0 , θ^0 , and charged K-decays. Complete analysis of all the events is still in progress. Four special cases of unstable particle decay have been fully analysed and the results published. (1) The first event shows the production of two γ -rays from the point of decay of a K-meson. (2) The next two events show strong evidence for the existence of a neutral particle of mass near about $1270 m_e$ and its cascade decays. These two pictures contain two V^0 -decays, in both of which one of the secondaries is found to be heavier than a pion and is found to decay into a thinly ionising particle at the end of its range. Approximate momenta and ionization estimates lead to a low Q -value of about 10 Mev for both the events if the secondaries are taken to be a K^- and a π -meson. This new particle is believed to be a bound excited state of an ordinary K -meson with a pion. (3) The fourth event represents the production and cascade decay of a charged primary. A charged K -decay associated with a V^0 event in the same picture has been found and the latter is quite inconsistent with a Λ^0 decay, but agrees with a θ^0 -decay. Measurement of the various angles and minimum momenta of the secondaries give a lower limit of $1460 m_e$ for the mass value of the primary charged unstable particle. The existence of a particle of this mass is well established from emulsion work.

Further work on unstable particles is being carried out at Darjeeling. In the meantime the construction of a bigger cloud chamber (100 cm $\times$ 80 cm $\times$ 45 cm) has been started which will be fitted with seventeen $\frac{1}{2}$ inch steel plates. This will help in obtaining pictures of decay events in which all the secondaries can be stopped inside the chamber and identified.

A.2.2. Sea level investigations

A medium size cloud chamber has been operating at Calcutta with a coincidence anticoincidence trigger so as to photograph stopped μ -mesons of different momenta in the extreme low energy end. The chamber is fitted with five $\frac{1}{2}$ inch Cu-plates and absorbers of Pb of various thicknesses were placed above the chamber so as to shift the momenta band by intervals of 30–40 Mev/c. The purpose of this investigation is to find the slow μ -meson intensity at sea-level near the equator which has not been obtained so far. This experiment has given no data for the scattering of μ -mesons of momenta ranging from 80 Mev/c to 150 Mev/c, in the Cu-plates inside the chamber. Definite evidence for anomalous scattering of non-electro magnetic origin even in this extremely low momenta group has been found, the cross section being $\sim 10^{-27}$ sq. cm.

The slow μ -meson flux at Calcutta has been found to be approximately flat upto 380 Mev/c with an average value of $5 \times 10^{-6} \text{ g}^{-1} \text{ sec}^{-1} \text{ sterad}^{-1}$ of air-equivalent. The subject matter of these two investigations is being written up in the form of two papers to be communicated shortly.

The following papers have been published :

1. Evidence for direct emission of a pair of γ -rays from the point of decay of a K -meson (*Phil. Mag.*, Aug., 1956).
2. Nuclear Size from Cosmic ray interactions (*Phys. Review*, 1st March, 1957).
3. Evidence for the existence of a heavy neutral K -particle and its cascade decay (*Nuovo Cimento*, May, 1957).
4. Cascade decay of a heavy K -meson (*Phil. Mag.*, in the Press).

A.2.3. IGY Programme

(i) *Meson telescopes*.—As a part of our programme of investigations during the International Geophysical year, two triple coincidence telescopes of cubical geometry, having an absorber of 10 cms. of lead between extreme trays, have been installed at Mayapuri, Darjeeling. These counter telescopes will furnish data regarding the time changes of the high energy component of cosmic rays. Each counter tray consists of 16 counters. In one telescope copper-in-glass type counters and in the other metal counters are being used. In metal counters a special type of glass copper joint (developed in our laboratory) has been used for insulation of the central electrode. Soft solder have been used in metal joints.

Each counter pulse is fed into one quenching unit comprising 12AT7 tubes. Output pulses from quench units are joined in parallel and fed into a cathode follower which in turn triggers the coincidence units. Scaled counts from triple coincidences of both the counter telescopes, along with time and temperature are being photographically recorded at every half-hour interval. An aneroid type microbarograph will soon be set up in the photo panel for photo registration of atmospheric pressure. Provision for photo registration of counts at every 15 minutes is now ready, and henceforth photo registration of counts will be taken at every 15 minutes interval during the 'alert' + SWI periods only. This 15 minutes or 30 minutes photo registration devices are operated by a clock work switching mechanism operating the camera at every pre-set time interval. In addition to this another electronic switching device for photo registration is being arranged. This latter method will actuate the photomechanism whenever cosmic ray intensity changes (increases or decreases) by more than 10% at the detecting telescopes. This additional photo registration will provide a method of recording the onset time of temporary increases of cosmic ray intensity during a solar flare and also the onset time of magnetic storms leading to decreases of cosmic ray intensity. This device will be put into operation from September 1957.

The data collected for each month from July 1957 onwards will be sent to the Cosmic ray committee for IGY in a standard form suggested in Circular No. IGY/4/57 dated 6-6-57.

(ii) *Neutron Monitor*.—The setting up of neutron monitor piles have been delayed since three neutron counters have been imported from Radiation Counter Laboratories (U.S.A.) only very recently. The necessary coupling arrangements are now under construction. The electronic circuit *viz.*, amplifier scalar power supply etc., have been assembled. A precision pulse generator has been wired up for calibration of the amplifier. One pile is expected to be in operation from the end of August 1957 at Calcutta. After a successful

run for two weeks at Calcutta the neutron monitor will be shifted to the high altitude station at Mayapuri, Darjeeling. In the meantime three more counters will be constructed and filled up in our vacuum system from BF_3 CaF_2 complex enriched in B_{10} . While filling these counters for the duplicate neutron pile, attention will be given to have the starting potentials and other characteristic close to that of the imported counters.

A.2.4 Ion-chamber Investigations

Investigations with pressure ionisation chamber which was kept in abeyance, since attention was diverted to the setting up of apparatus for the IGY programme, will now be taken up. These will be divided into two parts.

(i) *General intensity measurements.*—Continuous measurements on cosmic ray intensity will be taken by means of a pressure ionisation chamber (vol. 5 litres) coupled to a Woulf's electrometer. Hourly values of integrated intensity will be photographically registered. Subsequently a balancing system of measuring cosmic ray intensity will be tried.

(ii) *Investigations on cosmic ray bursts.*—Two small cylindrical ion chambers (vol. 1.5 litres) have been constructed. These will be operated as pulse-ion chambers using electron collection. Bursts induced by neutral components of cosmic rays will be investigated, employing the usual anticoincidence ring of G.M. counters for the elimination of bursts caused by charged particles. Special arrangement of G.M. counters will be made to select out the neutral components in the core of atmosphere showers. These are proposed to be under operation only during the Alert and S.W.I. periods.

A.2.5. Cosmic ray investigations using plastic phosphor

An arrangement has been set up to study showers and other associated phenomena in cosmic rays using a large volume plastic phosphor. Preliminary experiments for the measurement of transition curve in lead have shown promising results.

A. 3. Nuclear Physics

A.3.1. Investigations on thermal neutrons

In previous reports the development of an absolute method for the measurement of thermal neutron absorption cross section of nuclei had been discussed. Using a relatively simple apparatus it has been possible to reach the accuracy which is attainable in more elaborate arrangements using *e.g.* nuclear reactors. By using a mechanical arrangement it has been possible for us to average out the intensity of neutrons issuing from the source of thermal neutrons. With this apparatus the absorption cross section of chlorine in the form of CCl_4 has been found to be 31.9 ± 1.5 barns. This value agrees with the value obtained by pile oscillator methods.

Using a flexible neutron howitzer the scattering cross section of protons in liquid hydrogenous molecule has been measured. Application of Sachs and Teller theory of neutron scattering by bound protons to the experimental data permits the elucidation of the structure of the scattering molecule. From the measured cross section for water, it has been

found, from nuclear data alone, that H_2O is not a linear molecule. Experiments on glacial orthophosphoric acid indicates that unlike other oxy-acids hydrogen is rather loosely bound to the rest of the molecule. The data obtained also indicates that autocomplexes are not probably formed in the acid.

A.3.2 *Investigations on gamma rays*

An absorption type gamma ray spectrometer using a duMont 6292 photomultiplier has been constructed. The resolution of the apparatus at 1.3 Mev is about 7%, which is satisfactory. Using this energy selective device the total cross section of 1.33 Mev gamma rays in absorbers like Zn^{Br} , Cd, In, Sn, Hg and Pb has been measured. The analysis of the experimental data in terms of the recent theories indicate the necessity of revaluation of photoelectric and elastic scattering cross sections. Application of semi-empirical correction factors to theoretical cross section values brings them into close agreement with measured values.

A.3.3. *Radioactive Carbon Dating*

Preliminary details regarding the construction of an apparatus for radioactive carbon dating was reported last year. The large sized pyrex glass proportional counters which will contain the active sources as gaseous CO_2 is being tested. To reduce the back ground count of the proportional counter, the required antecoincides counted assembly is nearing completion. The electron circuit required for the measuring circuit is complete.

A. 4. Neutron Generator

Research worker Sri A. N. Banerjee (upto August 1956) assisted by Sri Barin Ghosh. Sri A. N. Banerjee resigned with effect from September 1956 and his successor Sri B. Mitra joined in June 1957.

The following contains an account of the work done on the scheme by Sri Barin Ghose from September 1956 with the assistance of some members of the Institute workshop staff.

Of the new apparatus for the production of 14 Mev neutrons with an yield equivalent to 50 curies Ra-Be source, reported in the last six monthly report the vacuum system of the accelerator tube and the discharge tube (ion source) is being remodelled. Originally the accelerator tube was built up in three sections of glass tubes of lengths 6" and 9" and $2\frac{1}{2}$ " containing the two aluminium electrodes of lengths 4" and 15" and connected to the glass discharge tube. These were sealed and held together by means of picien wax. But it has been found that the glass tubes being of larger diameter ($3\frac{3}{4}$ " inner diameter) and electrodes heavier than that in the prototype model, the picien wax joints often become sources of trouble. Due to heat produced during discharge it becomes difficult to maintain good vacuum as well as in keeping the axial alignment of the assembled portion. It is now proposed to have three new sections of the glass tubes with flanged ends with surfaces ground flat and ends made dead parallel; they could be sealed by placing greased O'rings made of neoprine in between the ground glass surfaces and the metal rings bearing the

electrodes, and clamping them together. Orders for these specially designed glass tubes manufactured by moulding them according to the three prescribed sizes, have been placed with Messrs Scientific Indian Glass Co. Ltd., Calcutta.

The following auxiliaries for the new discharge apparatus have been completed during the period :—

(a) Forming a part of the assembled apparatus is a T-shaped metal tube having an inner diameter nearly 3". This is connected with the discharge tube at one end and with the accelerator tube at the other. The third end is connected to the vacuum system. It has been machined out from a solid block of mild steel $8" \times 7" \times 4\frac{1}{2}"$ and tested for vacuum and found to be leak proof. The original T-tube made out from a galvanized T-joint could not be made leak-tight.

(b) A high frequency oscillator to initiate and maintain the discharge in the ion-source tube, with a frequency range 15–30 megacycles per sec and power output of 250 watts has been completed.

(c) A G.M. Counter, having end window of very thin mica has been installed for measuring the β activity after irradiation by fast neutrons of sample foils. The necessary circuits like stabilized high voltage supply unit, amplifier, discriminator and a scale-of-64 scaler circuit have been constructed and the apparatus is in running order.

Some of the component parts of the existing small neutron generator have been replaced and the electronic circuit repaired. It is again in satisfactory running order.

The following are nearing completion :

(a) A new scintillation counter with photomultiplier tube type 6260 for counting fast neutrons discriminating against the associated gamma radiation, by using Zns-impregnated lucite as phosphor. A plastic phosphor has also been proposed to be used with it.

(b) A high gain amplifier with voltage gain 10^5 having linear response through wide range of frequencies from 100 Kc/s to 500 kc/s.

(c) An ionization gauge for measuring extremely low pressures of the order of 10^{-5} and lower accurately is under construction.

A. 5. Ionising Radiation effects

Effect of ionising radiation on albino rats

It has been reported previously that the total urinary nitrogen excretion increases following exposure to ionising radiation in the range of L.D. 50 doses in albino rats. This increase takes place within 24 hours following radiation and is maintained for 3 to 4 days, coming down to normal level within one week. This increase in urinary nitrogen excretion is believed to be due to protein destruction in the tissue. Recent investigations on animals have shown that urinary excretion of urea and several amino acids increases to a very significant extent.

It has been planned to study in this Institute the changes in the concentration of the urinary amino acids, urea, creatinine and sulphate content, as also blood serum protein and haemoglobin content of albino rats after being irradiated with ionising radiation.

For the estimation of the amino acids, quantitative paper—chromatographic methods were adopted. Before proceeding with the experimental animals, concentration VS. optical density curves for the amino acids normally excreted by albino rats were obtained, using Beckmann spectrophotometer.

As a preliminary step towards a detailed investigation as to the nature of the increased nitrogen excretion in the urine of albino rats, three such rats kept on control diet, were exposed to a whole body radiation of (200 ± 30) r using a radium source. The same animals serve as controls prior to irradiation in order to eliminate individual variation. Twenty-four hours urine samples were collected and total nitrogen as also total solid excreted were estimated by standard methods. It was observed that following irradiation the total urinary nitrogen excretion is considerably decreased within 24 hours and is maintained for 3 to 4 days after which it increases and remains so upto the end of the 5th week after irradiation. Paper chromatogram of the urinary amino acids of these rats indicates qualitatively a considerable increase in the amounts of several amino acids of which glycine, taurine, glutamic acid, alanine are the most significant.

Detailed investigations are in progress.

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B. CHEMISTRY

B. 1. Physical and Biochemistry

B.1.1. Isolation and characterization of seed proteins

Work was commenced on the isolation of the protein constituents (with special reference to globulins) of two common oil-bearing seeds, namely *Sesamum indicum* (sesame) and *Brassica juncea* (rai), with a view to further studying the proteins by available physico-chemical methods, viz., electrophoresis and, if possible, sedimentation and diffusion analyses.

(1) Jones and Gersdorff (*J. Biol. Chem.*, **75**, 213, 1927) isolated two globulins (α - and β -) from white sesame seeds of Chinese origin. The α -globulin was obtained as a crystalline product and the β -globulin as an amorphous powder. From a study of the elementary composition and amino-acid data of the two globulins obtained by different methods of fractionation, Jones and Gersdorff concluded that globulins were distinct and homogeneous chemical entities. In the present work brown sesame seeds obtained through the courtesy of the Botany department are being used. The seeds were first decorticated and defatted. The powdered meal (8.07% N) was then extracted in the following solvents for 3-4 hours at about 25°C : (1) distilled water, (2) 10% NaCl solution, (3) 0.06M Na_2HPO_4 , 0.04M NaH_2PO_4 , 1M NaCl at pH 6.34 and nitrogen was determined in the filtrates from each extraction. Extraction of about 70% of the total nitrogen in the meal was accomplished in 10% NaCl. Jones and Gersdorff observed that dilution of the saline extract with 10 vols. of water produced an intense opalescence but caused no precipitation while in the present case, a precipitate was obtained by dilution even with 6 vols. of water, the precipitate freely redissolving in 10% NaCl. Fractional precipitation with ammonium sulphate at 20% and 80% saturation gave two fractions, the former being larger in quantity. While both the precipitates redissolved freely in 10% NaCl, the 20% fraction was almost insoluble in 0.06M phosphate buffer at pH 6 and 8 and the 80% fraction was more soluble at pH 8 but sparingly soluble in the region of pH 6. A preliminary paper electrophoretic experiment with a solution of the 80% fraction in phosphate buffer at pH 8 gave two zones indicating two components or the breakdown products of a single component. Further work is in hand.

(2) The seeds of *Brassica juncea*, obtained from the Botany Department, were subjected to the following procedures of extraction : (1) defatted meal obtained from oven-dried seeds at 110°C was extracted with 10% NaCl for 3-4 hours at about 25°C; (2) decorticated seeds were lightly ground and the coarse meal was extracted with 10% NaCl for 2-3 hours at 25°C. Both the extracts, after centrifuging and filtering off the suspensions, were saturated to 70% with ammonium sulphate and the resulting precipitates were removed by centrifugation. The clear supernatant did not give any further precipitate with ammonium sulphate. The precipitate, which was freely soluble in water and phosphate buffers at pH 6 and 8, was subjected to paper electrophoresis at pH 6 and 8 and two distinct zones were obtained at both the pH values. *Emm*

The extracts did not produce any opalescence or precipitate on dilution but on dialysis for 2-3 days in cold (4-6°C) against distilled water gave a precipitate which, however, could not be redissolved in 10% NaCl or usual buffers indicating probable denaturation during dialysis, a fact which has been observed by various workers investigating other seed globulins.

B.1.2. *Electrophoretic analysis of sera of allergic patients*

The work on the electrophoretic analysis of sera of allergic patients before and after treatment with autoantihuman serum floccule was undertaken in collaboration with the Department of Pathology, Calcutta School of Tropical Medicine. The electrophoretic patterns of sera obtained by Tiselius technique did not reveal any significant difference between the normal serum and that of an allergic patient. On the other hand, the sera of patients before treatment and after (when accompanied with a therapeutic relief), indicate an alteration of the pattern in the neighbourhood of the β -globulin peak pointing to some probable reorientation of the components of the sera after treatment. The results are being subjected to further check to confirm the observation. Further, comparison of the patterns obtained from normal human serum, rabbit serum and from the supernatant left after centrifuging off the floccule formed by mixing the two sera, showed that in the pattern of the supernatant the globular proteins of the two constituents had practically vanished. It thus appears that the floccule consisted predominantly of the globulin fractions of the rabbit and the human serum. Further work with fresh batches of sera is in progress.

B.1.3. *Gas-phase chromatography*

It has been proposed to set up a gas-phase chromatographic apparatus with some special features, such as, (1) interchangeable columns, (2) interconnectable columns containing different liquid phases and (3) a special sample-chamber which can be used for both gaseous and liquid samples.

A skeleton apparatus has been set up using a charcoal column and has been tested with a mixture of methyl alcohol, ethyl alcohol and diethyl ether. A complete separation of the components was achieved.

The progress in completing the apparatus has, however, been retarded due to the non-availability of precision pressure and flow control units.

B.1.4. *Apparent dissociation constants of some alkaloids of the Berberine group*

The apparent dissociation constants of berberine, neprotine, and dihydroberberine have been evaluated from the optical densities of their solutions in buffers of different pH values. The optical densities have been measured by a Beckmann spectrophotometer. The dissociation constants of these alkaloids have been found to be related to the degree of elongation of the spots when the alkaloids are chromatographed on paper with buffer solutions.

B.1.5. *A colorimetric method for the estimation of compounds $-\text{CH}_2-\text{CO}-\text{CHOH}-$ or $-\text{CH}(\text{OH})\text{CHO}$ groups*

A violet coloration is obtained when compounds containing $-\text{CH}-\text{CO}-\text{CHOH}-$ or $-\text{CH}(\text{OH})\text{CHO}$ groups are warmed with 1 : 2-dinitrobenzene in presence of alkali, and

this color turns yellow on keeping. The intensities of the two colors have been estimated using varying amounts of glucose with the help of a Beckmann spectrophotometer. Results obtained so far show that the yellow color is more stable and changes more linearly with the concentration of glucose than the violet color. Studies on the effect of varying the concentration of 1 : 2-dinitrobenzene and alkali on the color intensity are in progress.

B.1.6. Antimicrobial activity of some plant constituents

(a) Seventeen natural coumarins of Indian origin were examined for their antifungal activity against *Curvularia lunata* and *Aspergillus niger*. Of these psoralen, seselin, luvangetin, and xanthyletin have been found to be significantly active against *C. lunata*.

(b) Antimicrobial activity of mesuol and related constituents of *M. ferrea* has also been studied. Mesuol and a new phenolic constituent have been found to be fairly active against *Staphylococcus aureus*.

B. 2. Plant Chemistry

B.2.1. Survey of saponin-bearing plants of India

A survey of the saponin-bearing plants has been undertaken with the object of finding out new sapogenins which might be utilised for the large-scale preparation of cortisone and sex hormones. Preliminary investigation of the following plants have been carried out : (1) *Barringtonia acutangula* Gaertn., (2) *Luffa cylindrica* Roem., (3) *Luffa acutangula*, (4) *Albizzia lebbek*, (5) *Vigna catieng*, (6) *Polianthes tuberosa*, (7) *Phaseolus radiatus*, (8) *Lens culinaris*, (9) *Polygonum barbatum*, (10) *Polygonum orientale*, (11) *Ficus hispida*, (12) *Prunus nepalensis*. Of these the first eight have been found to contain saponin.

Barringtonia acutangula Gaertn.—From the seeds a crystalline saponin has been isolated as its calcium salt, m.p. 250–255°. The sugar moiety has been characterised as rhamnose, galactose and arabinose. Hydrolysis of the crude saponin gave a mixture of neutral and acid sapogenins. From the neutral fraction, three sapogenins (I), (II) and (III) have been obtained in a state of purity. The sapogenin (I), m.p. 249°, $[\alpha]_D^{30} + 6$ (CHCl₃), has been named Acutagenol A. The sapogenin (II), m.p. 306–312°, $[\alpha]_D^{26} + 39.5^\circ$ (dioxane), has been named Acutagenol B. The sapogenin (III), m.p. 305°, which depressed the m.p. of Acutagenol B, has been named Acutagenol C. These sapogenins responded to Liebermann-Burchardt reaction and gave pale yellow colour with tetranitromethane. Acutagenol B formed a pentaacetate, m.p. 217°, $[\alpha]_D^{30} + 18^\circ$ (alcohol) and a pentabenzoate, m.p. 312–315°, $[\alpha]_D^{26} + 22.6^\circ$ (dioxane). Acutagenol B gave under different experimental conditions, two partially benzoylated products of m.p. 175° and 275° respectively. The latter, when oxidised with pyridine-chromic acid complex, gave a product, m.p. 276°, which depressed the m.p. of the parent compound. Acutagenol B appears to contain a hindered double bond, as its penta-acetate and pentabenzoate consume 0.7 mole of perbenzoic acid in 15 days. It also consumed one mole of periodic acid indicating the presence of an α -glycol system. Acutagenol B, when oxidised with pyridine-chromic acid complex, gave a product, m.p. 251°. Acutagenol C formed an acetyl derivative m.p. 230–232°, $[\alpha]_D^{35.5} + 89.9^\circ$ (CHCl₃)

The neutral fraction of the sapogenin mixture appears to contain some fractions other than those reported above and attempts are being made to purify them.

The acid sapogenin fraction, on esterification with diazomethane gave two methyl esters (IV) and (V). The methyl ester (IV), m.p. 253–254°, did not depress the m.p. of an authentic sample of methyl barringtogenate. The methyl ester (V), m.p. 301–303°, has been named methylacutagenate. It contains an α -glycol system. It responds to Liebermann-Burchardt reaction and is unsaturated. Further work is in progress.

Luffa cylindrica Roem.—A crystalline saponin, m.p. 271° (decomp.) was isolated from the seeds. It furnished, on hydrolysis, an acid sapogenin in good yield and a neutral sapogenin in extremely poor yield. The acid sapogenin has been found to be identical with oleanolic acid.

The neutral sapogenin fraction, m.p. 176–177°, has been tentatively assigned the molecular formula $C_{30}H_{48-50}O_3$. It responds to Liebermann-Burchardt reaction and is unsaturated.

Luffa acutangula.—From the ether extract of the seeds, a neutral compound, m.p. 275°, has been isolated and attempts are being made to isolate the bitter principle in crystalline state. From the alcoholic extract, a crude acid sapogenin has been obtained and is being purified.

Albizzia lebbek.—From the alcoholic extract of the crushed seeds, a neutral sapogenin, m.p. 304°, has been obtained. Attempts are being made to characterise it.

Vigna catiung.—The alcoholic extract of the seeds contains a good quantity of saponin which has not yet been obtained in a pure state.

Polianthes tuberosa.—From the tubers of the plant, two neutral sapogenins (I) and (II), m.p. 205° and 255° respectively, have been isolated. Compound (II) has been found to be identical with hecogenin.

Phaseolus radiatus.—Attempts are being made for the isolation in the pure state of the alcohol-soluble saponin of the seeds.

Polygonum barbatum.—From the leaves, two products, a sterol, m.p. 130°, and a neutral compound, m.p. 79–80°, have been isolated. No saponin could be isolated.

Prunus nepalensis.—From the petroleum ether extract, two crystalline triterpenoid compounds (I) and (II) have been isolated, m.p. 256° and 276° respectively. They do not depress the m.p. of authentic samples of friedelin and epi-friedelinol respectively. No saponin could be isolated from the bark.

B.2.2. Alkaloid Survey

The survey of alkaloidal potentialities of the local flora, including the non-medicinal plants, has been continued. Nearly 30 plants have been screened on a semi-quantitative basis. Of these ten showed the presence of alkaloids, viz., *Amoora rohituka*, *Beaumontia grandiflora*, *Beilschmidia roxburghiana*, *Canthium parviflorum*, *Clitoria ternatia*, *Diplospora singularia*, *Hunteria corymbosa*, *Jatropha gossypifolia*, *Michelia champaca*, *Pterocarpus indicus*. The rest were found to be free from alkaloids.

The alkaloids of *J. gossypifolia* and *B. grandiflora* were found to be water soluble. From the chloroform extract of the leaves of *J. gossypifolia*, which was free from alkaloids, a sterol, m.p. 136–137°C, has been isolated and identified as β -sitosterol. Besides, a low-melting neutral compound was obtained, m.p. 85–86°.

From the bark of *H. corymbosa* which is fairly rich in alkaloidal contents, a colourless needle-shaped base m.p. 220–223°C (decomp.) has been obtained. Attempts are being made for its characterisation.

B.2.3. Chemical examination of *Mesua ferrea* Linn.

From the kernel of the seeds of *M. ferrea*, mesuol and another phenolic constituent (m.p. 136°C) were isolated.

The previous molecular formula of the compound ($C_{23}H_{22}O_5$) has been confirmed. (*J. Ind. Chem. Soc.*, 1940, **17**, 277). Also the presence of two phenolic hydroxyl groups is supported by infrared spectra as well as by the determination of numbers of active hydrogen. The I.R. spectrum also indicates presence of a lactone, and C-methyl groups. The ultraviolet spectrum of mesuol shows a maximum at 300 $m\mu$ and a marked shoulder at 230–240 $m\mu$. The latter is highly suggestive of two independent chromophores in the molecule. The presence of three double bonds has been indicated by hydrogenation experiments as well as by perbenzoic acid titration. Ultraviolet spectrum of the hydrogenated product (m.p. 181°C) appears to be characteristic for the methyl phloroacetophenone nucleus.

Mesuol on hydrolysis yields an acid of m.p. 160°C. Oxidation of mesuol with 1% alkaline $KMnO_4$ in cold gave a crystalline product (m.p. 228–230°C). Further studies on the structure of mesuol are in progress.

B.2.4. Chemical examination of *Citrus* genus.

(a) One of the isolated neutral constituents reported previously from a variety of *Citrus medica* has been identified as β -sitosterol.

(b) Of the four constituents previously obtained from the bark of *C. decumana*, the lactone (m.p. 270–282°C) has been identified to be limonene. The steroidal constituent has been identified as β -sitosterol. By paper chromatographic technique an alkaloid (R_f 0.96 in *n*-butanol–HAc–water) has been detected in the bark.

B.2.5. Chemical examination of *Murraya Koenigii* Spreng.

β -Sitosterol has been isolated from the leaves of *M. koenigii*. The presence of murrayin has been detected by paper chromatographic technique (R_f 0.76 using water as the solvent). The leaves contain a water-soluble alkaloid.

B.2.6. Paper chromatographic studies with some plant constituents.

Circular paper chromatographic studies with berberine and some of the related alkaloids have been done. The results show that unidimensional technique is preferable for separation of berberine and related alkaloids.

B.2.7. Chemical examination of seeds of *Saraca indica* Linn.

The seed fat (m.p. 75–78°C) has been examined for its physical characteristics. The composition of the mixed fatty acids has been determined by spectrophotometric method. A steroid and a flavonoid constituent have been detected in the seeds.

B.2.8. Constituents of Indian spices.

(a) The flavone glycoside from *Cuminum cyminum*, which had yielded the aglycone apigenin (*vide* previous report), has been obtained as colourless needles, m.p. 228–232° and identified as apiin.

The second glycoside could not be characterised. The corresponding aglycone, bright yellow rectangular plates, $C_{15}H_{10}O_6$, m.p. 315–318°(d) (previously reported 314–317°) gave a tetra-acetate, m.p. 226–228°, and a trimethyl ether, m.p. 167–168° and was identified as luteolin (5 : 7 : 3'-4'-tetrahydroxyflavone).

(b) The reputedly stimulant and carminative seeds of *Carum copticum* furnished a steroidal fraction, m.p. 120–138°, in low yield. A yellow crystalline flavone, m.p. 291–294°, has also been isolated in extremely poor yield (0.0011%). It has a R_f value of 0.31 in phenol-water and 0.62 in BuOH-HAc-H₂O (4 : 1 : 1). The quantity of the colouring matter was insufficient to permit further work.

(c) The root and stem of *Coriandrum sativum* yielded a steroidal fraction, m.p. 125–130° and a neutral compound, m.p. 78–83°, both in very low yields. No flavonoid substance could be isolated.

(d) Search for flavonoid components.—The preliminary investigations by colour reactions and paper chromatography of the following spices have been made.

- (i) *Foeniculum vulgare* (seeds)
- (ii) *Trigonella foenum-graecum* Linn. (seeds)
- (iii) *Cinnamomum tamala* Fria (leaves)
- (iv) *Eugenia aromatica* (clove)
- (v) *Peucedanum graveolens* Benth & Hook. (seeds).

Flavonoid constituents could be located in (iv) and (v) only.

B.2.9. Investigation of *Eupatorium odoratum* Linn.

The leaves of *E. odoratum*, a shrub and a fish poison, have furnished a bright yellow crystalline flavone, m.p. 232–233°, the structure of which is being established.

B.2.10. Constituents of *Thymus serpyllum* Linn.

Besides the known ursolic acid, β -sitosterol has been obtained from this herb.

B.2.11. Synthetical experiments in the coumarin series

iso-Imperatorin has been prepared as an intermediate compound for the synthesis of psoralidin, a constituent of *Psoralea corylifolia* Linn. An isomeric psoralidin methyl ether, $C_{17}H_{16}O_4$, has been prepared as colourless crystalline plates, m.p. 111–113°, by a rearrangement of *iso*-imperatorin and subsequent methylation of the phenolic product.

B.2.12. *The constitution of the two triterpene acids from the galls of Pistacia integerrima Stewart*

Pistacic acids A and B (now renamed as pistacienonic acids A and B) have been shown, in the previous report, to be keto-carboxylic acids of the molecular formula, $C_{30}H_{46}O_3$. The methyl esters gave the corresponding hydroxy compounds on reduction with sodium borohydride; methyl pistacienolate A, so obtained, melted at $123-124^\circ$, $[\alpha]_D -45.4^\circ$. Lithium aluminium hydride reduction of methyl pistacienonate A gave the expected diol, $C_{30}H_{50}O_2$, m.p. $182-184^\circ$. The methyl esters gave a positive Zimmermann test, characteristic of the 3-keto-group in triterpenoids. Methyl pistacienolate A on oxidation with chromium trioxide-pyridine complex gave back the keto-ester.

The infrared absorption spectra of methyl pistacienonates A and B, which are closely allied, showed bands at 1706 cm^{-1} (superimposed six-ring ketone and carbomethoxy group) and at 1645 cm^{-1} and 1605 cm^{-1} (in the double bond region). Other bands present are at 1365 and 1385 cm^{-1} (*gem*-dimethyl group) and at 1438 and 1150 cm^{-1} .

Hydrolysis of the methyl esters with 5% alcoholic potassium hydroxide gave almost quantitative yields of the acids showing that the carboxylic group is unhindered in both.

Methyl pistacienonate A and the acetyl derivative of methyl pistacienolate A consumed two moles of perbenzoic acid in 24 hours, showing the presence of two reactive double bonds in them. Methyl pistacienonate B, on the other hand, contained only one double bond reactive to per-acid and since its molecular formula and other properties are so close to the other methyl ester, the second double bond in it may be more hindered sterically. The methyl esters showed no selective absorption in the ultraviolet above $2200\text{ \AA}$ proving the absence of a conjugated diene system.

Acetyl of methyl pistacienolate A, on hydrolysis with cold alcoholic potash, gave pistacienolic acid, A, m.p. $200-202^\circ$, $[\alpha]_D -46.2^\circ$ ($CHCl_3$), the acetyl derivative of which melted at $176-180^\circ$. Oxidation of methyl pistacienonate A with neutral potassium permanganate gave an acid, m.p. $212-213^\circ$.

Hydrogenation of methyl pistacienonate A in acetic acid, over Adam's catalyst gave the hydrogenated product, m.p. $88-90^\circ$, which still contained unsaturation. Acetyl of methyl pistacienolate A, on oxidation with chromic oxide in acetic acid medium, gave a yellow solid m.p. $121-125^\circ$.

The formula $C_{30}H_{46}O_3$ for pistacienonic acid A with two double bonds suggests a tetracyclic structure. The molecular rotation differences of acetyl and keto groups, which are $+92^\circ$ and -121° respectively show very close similarity to those of butyrospermol, a tetracyclic triterpene alcohol of known structure. The negative shift in the molecular rotation on conversion of the alcohol to the keto-group is so characteristic of the butyrospermol series that a possible relationship of pistacienonic acid A to butyrospermol is indicated. With the idea of disrupting the molecule at the double bond, through epoxidation and subsequent cleavage with periodic acid, the epoxide of acetyl methyl pistacienolate A was prepared and was hydrolysed with boiling 1% ethanolic 2N-sulphuric acid. But neither the epoxide nor the hydrolysed product could be crystallised.

As a possible double-bond isomerism might be existing between methyl pistacienonate A and methyl pistacienonate B, the former was tried to be converted into the latter under acid catalysed conditions. The product obtained, however, yielded no crystalline solid.

Attempts were also made to convert the carboxyl function of the acid or its suitable derivative into a methyl group. For this purpose the methyl ester was reduced with lithium aluminium hydride and the diol so obtained was further oxidised with chromic oxide-pyridine complex. This afforded a mixture of neutral compounds, which did not yield to purification and hence the proposed further Wolf-Kishner reduction of the keto-aldehyde had to be abandoned.

Barton and Seoane (*J. Chem. Soc.*, 1956, 4150) and Seoane (*ibid.*, 1956, 4158), working on gum mastic isolated two new tetracyclic triterpene acids, masticadienonic acid and its isomer, which they characterised as tirucall-7-en-27-oic acid and tirucall-8-en-27-oic acid respectively. The published physical constants of these acids and their derivatives are very close to those of our pistacienonic acids A and B and the complete identity of the two sets of compounds has been shown by the mixed melting point determinations.

B.2.13. *Other constituents of Pistacia integerrima*

Three neutral compounds have also been located in the galls of *P. integerrima*. They are : (i) a waxy substance of m.p. 75–77° which seems to be a hydrocarbon from its physical and chemical properties, (ii) β -sitosterol and (iii) a triterpene alcohol, $C_{30}H_{50}O$, of m.p. 132–133°. It gave an acetate of mp. 159–161°. The molecular formula and the m.p.'s of the alcohol and its acetate agree with those of tirucallol.

B.2.14. *Sapogenins from the seeds of Dodonea viscosa*

Parihar and Dutt (*Proc. Ind. Acad. Sci.*, Sec. A, 1947, **26**, 56) reported the presence of a steroidal sapogenin of m.p. 249°, named dodogenin, in the seeds of *D. viscosa* and to which they assigned the formula $C_{23}H_{36}O_8$. We isolated from the same source a neutral triterpenoid sapogenin of m.p. 300–302° agreeing well with the physical properties recorded for dodogenin. This compound gave in the Liebermann-Burchardt reaction a pink colour. Another neutral crystalline compound of m.p. 155–160° and giving in the Liebermann-Burchardt test a colour changing from pink to blue and finally green, is also present in the seeds. Further work is in progress.

B.2.15. *Chemistry of the gum "Guggul"*

The gum-resin, "Guggul" has been chemically examined for the extractable components present in it. Two neutral compounds of m.p. 210–216° and 134–138° have been isolated from it. The work is in progress.

B.2.16. *Chemical investigation of genus Ficus*

The systematic investigation of different species of *Ficus* has been continued and some more triterpenoid and steroidal compounds have been isolated. Detailed chemical and physical studies reveal the identity of the compounds as shown below :

F. bengalensis: (i) α -Amyrin acetate; (ii) epi-friedelinol; (iii) β -sitosterol.

F. heterophylla: (i) α -Amyrin; (ii) β -sitosterol.

F. elastica: (i) Friedelin; (ii) α -amyrin acetate.

F. krishna: (i) α -Amyrin acetate; (ii) epifriedelinol; (iii) β -sitosterol.

β -Sitosterol has also been located in *F. hispida*, *F. infectoria* and *F. benjamina*.

The chemical investigation of *F. cunia* has been taken up.

It is interesting to note that all the four representative members of pentacyclic triterpenes (namely lupeol, α -amyrin, β -amyrin and friedelin) are present in *Ficus* species. The occurrence of friedelin and epifriedelinol along with α -amyrin acetate is interesting from the point of biosynthesis of pentacyclic triterpenes.

B.2.17. *The Constitution of Clerodin, the bitter principle of Clerodendron infortunatum*

Clerodin, the bitter principle of *C. infortunatum*, was isolated in this laboratory by Banerjee (*J. Indian Chem. Soc.*, 1937, **14**, 51) who assigned to it the formula $C_{18}H_{18}O_3$ and studied some of its physical and chemical properties. Later on, Chowdhury and Dutta (*ibid.*, 1951, **28**, 295) suggested the formula $C_{28}H_{40}O_8$ from re-determination of its molecular weight. They also suggested the presence of $-OH$ and CH_3CO- groups from I.R. spectra and chemical evidences.

In course of our study on the constitution of clerodin, we have observed that the formula $C_{28}H_{40}O_8$ is apparently correct, but it shows the absence of $-OH$ group. It can be reduced by sodium borohydride to a hydroxy compound which is different from de-acetylated clerodin. Clerodin contains three acetoxy groups and can be hydrolysed with dilute alkali in cold to a substance, m.p. $250^\circ C$. Clerodin is unsaturated and could be catalytically reduced to a product, m.p. $170-171^\circ C$. It also reacts with two moles of perbenzoic acid. It contains four C-Methyl groups and undergoes reduction with lithium-aluminium hydride to a compound, m.p. $221-225^\circ C$. It has no selective absorption over $220\text{ }\mu$.

B. 3. On the nature of the irritability substances present in *Mimosa pudica* Linn.

B.3.1. In the previous year the presence of three aminoacids in the sap obtained directly from the stimulated pulvinus of *M. pudica* was reported. It was thought worthwhile to find out if the saps of the non-motile plants contain the same free amino-acids as *M. pudica*. The results of paper chromatographic experiments with saps of a few plants are reported in Table I. A large number of plants will be studied in the coming year to find out the free amino-acid picture of saps of different types of plants and correlate it, if possible, with the motility.

TABLE I

Plant	Nature of the plant	Amino-acids detected
<i>Averrhoa carambola</i> Linn.	Semi-motile	Nil
<i>Bryophyllum indicum</i> Salisb.	Non-motile	Nil
<i>Clitoria ternatea</i> Linn.	„	Nil
<i>Erythrina indica</i> Lam.	„	Nil
<i>Mimosa spegazzini</i>	Motile	2 amino acids. (not identified)

B.3.2. A seasonal variation in the free amino-acid composition of the sap of *Mimosa pudica* obtained directly from the stimulated pulvinus has been observed. It will be apparent from Table II that the glutamic acid in the sap disappears when the plants become less sensitive due to age or change of season. The sap composition was studied at intervals of time, and the results obtained are given in table II.

TABLE II

Date of collection of sap.	No. of amino-acid spots located	Nature of the amino-acids
15-9-56	3	Glutamic acid, glycine, alanine.
16-11-56	2	Glycine, alanine.
24-11-56	"	"
5-12-56	"	"
20-12-56	"	"
1-2-57	"	"
11-2-57	"	"
4-3-57	"	"
21-3-57	"	"

The disappearance of glutamic acid in the sap of *M. pudica* during cold and dry seasons, when the plants have low sensitivity, seems *prima facie* to indicate some role of glutamic acid in the contractile action of *M. pudica*. These experiments, however, will have to be repeated before any definite conclusion could be drawn.

B. 4. Radiochemistry

B.4.1. *Synthesis of isotopically labelled compounds*

A project has been undertaken to synthesise isotopically labelled compounds in the laboratory, particularly, those which are known to play important roles in plant metabolism. An investigation on the possibilities of the synthesis of malic acid -2, 3- C^{14} from fumaric acid-2, 3- C^{14} has been undertaken. When fumaric acid was heated with water in a sealed tube at 170°C for 72 hrs. and the reaction mixture subjected to paper chromatography in ethanol-ammonia-water (90 : 5 : 5) and the chromatogram observed under ultraviolet light (2537Å) spots corresponding to both malic and fumaric acids were detectable. The yield of malic acid was however near about 50%. The yield could be increased considerably when a little NaOH, pumice stone or the ion-exchange resins Dowex 1 and 50 were used as catalysts.

B.4.2. *Sulphur metabolism in plants*

The investigation on the path of sulphate reduction by green plants has been completed. The initial incorporation of sulphate - S^{35} into taurine - S^{35} has been shown to be non-

enzymatic and exchange reactions do not play any significant part. On the basis of available evidence it appears that the SO_4^{2-} ion is reduced to SH through several steps. The following scheme is suggested tentatively : $\text{SO}_4 \rightarrow \text{HSO}_3$ (taurine) $\rightarrow \text{HSO}_2$ (hypotaurine) $\rightarrow \text{HSO} \rightarrow \text{SH}$. No radioactivity was detected in β -mercaptopyruvic acid, mercaptopropionic acid, mercaptoethylamine or thioglycolic acid.

When $\text{Na}_2\text{S}^{35}\text{O}_4$ was supplied to pea plants and auto-radiographs of plants were taken after 15 min., 30 min., 1 hr., 2 hrs., 4 hrs., and 6 hrs. sulphate S^{35} was found to be transported to the top-most leaf first, in large amounts. Radioactivity in lower leaves increased with time. When the 6th, 5th, 4th and 3rd leaves of a number of plants fed $\text{Na}_2\text{S}^{35}\text{O}_4$ through the roots for 1 hr. were pooled together, and extracted and chromatographed two-dimensionally the top-most (6th) leaf was found to contain at least 25 S^{35} -labelled compounds, the number decreasing in lower leaves until in the 3rd leaf only inorganic sulphate was detectable.

Large number of S^{35} -labelled compounds were also detected in the roots after 1 hr., methionine predominating. Apparently no organic S-compound was translocated to the aerial parts during this period, nor did any such compound come down from the top.

B.4.3. *Photosynthesis : Thioctic acid and photosynthetic CO_2 fixation*

The role of thioctic acid in photosynthesis has been further investigated. It has been found that when quinone, which acts as a hydrogen acceptor in the Hill Reaction, is added to media in which cells of *Scenedesmus obliquus* are allowed to metabolise C^{14}O_2 in light, a promotion in the rate of photosynthetic CO_2 fixation is observed with low concentrations of thioctic acid.

B.4.4. *Carbon dioxide fixation in relation to auxin-induced growth and inhibition*

Indole acetic acid has been found to stimulate C^{14}O_2 fixation by *Avena* coleoptiles as also *Avena* roots. In absence of auxins bulk of the radioactivity incorporated was detectable in the phosphate esters, sugars, a few organic acids and amino acids. In *Avena* coleoptiles in absence of auxins aspartic acid constituted more than one-fourth the total radioactivity detectable in the alcohol-soluble fraction; with the addition of a little auxin this dropped down to less than 1%. This fall is accompanied by a large increase of radioactivity in malate and sugar phosphates. In *Avena* roots, however, no such decrease in aspartate has been noticed.

B.4.5. *Carbon dioxide fixation and photoperiodism : The low intensity light process*

In the low intensity light process red light in the region of 6600 Å nullifies the effect of the previous photoperiod, and this effect in turn is reversed by light of the far red region. This low intensity light process of photoperiodism in relation to C^{14}O_2 fixation by Biloxi soyabean, Wintex barley and cocklebur leaves has been investigated.

The long day Wintex barley and the short day cocklebur were used. The effect of red and far red light applied 6 hrs. after the commencement of the dark period, on the products of C^{14}O_2 fixation in the dark period and the products of photosynthetic CO_2 fixation

in the previous light period has been studied. Red light was applied for 30 min. and 60 min. followed by far red light for 30 min., 60 min., and 90 min. Intervening dark periods between the red and far red exposure is known to reduce the effectiveness of the far red light; a group of plants treated with 1 hr. red light was subjected to 1 hr. far red exposure after dark intervals of 15, 30 and 60 minutes. At the end of each treatment the plants or leaves were extracted in hot 80% ethanol. The aliquots of the concentrated clear extract were subjected to paper chromatography and auto-radiography for separation and detection of the metabolites.

Darkness, red or far red light affected the rate of decarboxylation and hydrolytic reactions differently depending on the photoperiodic behaviour of the plant. The immediate effect of red light on the products of dark or photosynthetic $C^{14}O_2$ fixation was considerable decarboxylation. Of particular interest among the individual compounds were the phosphate-esters and malic acid. In the dark-fixation of $C^{14}O_2$ in the long day barley bulk of the label appeared in phosphate esters, very little appeared in malate. In photosynthetic $C^{14}O_2$ fixation considerable activity was detected in malate. Label in malate decreased due to exposure to red light. In short day Cocklebur opposite was the case *i.e.*, radioactivity in malate increased with exposure to red light. When the far red light followed the exposure to red, in barley label appeared in malate, whereas it gradually disappeared in Cocklebur. This effect increased with increase in the number of inductive cycles.

In barley the effect of red light could not be substituted by naphthalene acetic acid in concentrations of 1-10 mg/l as indicated in experiments in which auxins were applied to the plants during the same period.

When barley or cocklebur plants were allowed to photosynthesise $C^{14}O_2$ in red light, the usual products of photosynthesis were observed except malate. In cocklebur abundant radioactivity was detected in succinic acid which was completely metabolised away when far red light followed the red light treatment.

B.4.6. *Translocation of photosynthates as a function of photoperiodism*

It is generally believed that during the period of photoperiodic induction some substance(s) is synthesised in the leaves which is translocated to the growing points where floral primordia are initiated. The translocation of the products of photosynthetic fixation of $C^{14}O_2$ out of the leaves of cocklebur has been studied at periodic intervals during the inductive dark period and the light period which followed it. The rate of translocation was initially very slow, more than doubled over the critical dark period and then slowed down again. The rate slowed further when the leaves were subjected to light. The experiment was discontinued after 6 hrs. of light treatment. The leaves at this stage contained a large number of compounds not detected among the normal products of photosynthesis or in the dark period which follows the light period during induction treatment.

C. BOTANY

C. 1. Plant Biochemistry

C.1.1. *Studies on the Biochemistry of Crown Gall*

C.1.1.1. *Bacteria-free Crown Gall tissue.* The use of various antibiotics, viz., Pyocyanin, Streptomycin, Penicillin and Actinomycin, for obtaining bacteria-free gall tissue has been mentioned in previous years' report. From the preliminary results it was hoped that the use of streptomycin would solve the difficult problem of obtaining bacteria-free gall tissue. This observation was confirmed during experiments of this year and Hollyhock bacteria-free gall tissue has been growing satisfactorily in culture medium for more than 16 months. Of the three media tried, i.e., White's basal medium, Sunflower medium and Tobacco medium of Hildebrandt, Riker and Duggar, Tobacco medium was found to be the best from the point of increase in fresh weight during 21 days incubation period ($25^{\circ}\text{C} \pm 1^{\circ}\text{C}$). Further work is in progress regarding the final concentrations of individual nutrients of Tobacco culture medium to be used as an improved Hollyhock culture medium. As regards other antibiotics tried, gall tissue was damaged with Penicillin and Actinomycin. Pyocyanin, however, failed to render the gall-tissue free of bacteria as may be expected from the fact that the action of Pyocyanin on *Ag. tumefaciens*, the causal organism, is bacteriostatic and not bactericidal in nature. Keeping in mind the scheme of culturing a distinct set of bacteria-free gall tissue from at least five different plants belonging to different plant families, attempts were made to culture bacteria-free gall tissue of Bryophyllum and Tropaeolum. The method was essentially the same as that in case of Hollyhock. Bacteria-free Bryophyllum gall tissue has been successfully grown in culture medium using Sunflower culture medium of Hildebrandt, Riker and Duggar. In case of Tropaeolum gall tumour, though the tissue was freed from bacteria, the culture medium used seemed to be the determining factor for the continued growth as the tissue failed to grow gradually after two months' sub-culture. The medium used was that of Robbins' modified medium (1946). During next flowering season a second attempt to grow the Tropaeolum gall tissue in various modified media based on Robbins' basal medium will be attempted along with that of Marigold and Balsam gall tumour tissue.

C.1.1.2. *Single cell bacteria-free gall tissue.* It is obvious that single cell culture of plant tissue would be more advantageous for biochemical and physiological work than the tissue culture in the form of small pieces. With this view in mind experiments were undertaken with Hollyhock bacteria-free gall tissue as the test material to obtain single cell culture. Potassium oxalate in different concentrations was used in the culture medium without any added calcium salts, the calcium salts being replaced by equivalent amount of sodium salts. The addition of oxalate was to eliminate traces of calcium present in the culture medium as impurity from other salts. The cultures were grown on a reciprocal shaker. After 21-days growth period the cultures turned brown and finally failed to grow any more. In some cases cell aggregations were observed in the medium the viability of

Cell

which was determined by their capacity to reduce Triphenyl tetrazolium salt. As the presence of even small concentration of oxalate tended to produce toxic effect on tissue cultures another experiment was undertaken in which tissue cultures were subjected to mechanical vibration effect. This method has been reported by Nickell in 1956 in case of *Phaseolus* tissue culture (normal) in which he claims to have grown single cell cultures for about 48 months. The method tried was essentially the same as that of Nickell with minor variations. Microid shaker (wrist action), 300 strokes/minute was used to shake four 250 cc. Erlenmeyer flasks containing 15 cc. medium each. Transfer was given after 7-days growth period. After 3 months growth, a clump of cells and a few individual cells from one single piece of tissue were observed in the medium. Viability of the cells and the cell clump were determined by using tetrazolium salt as stated before. This experiment could not be continued further for want of a suitable mechanical shaking device which could accommodate a larger number of flasks at a time. Efforts are being made to procure one such device.

C.1.1.3. *Respiration studies of normal and gall tissue.* Respiration of normal tissue of Bryophyllum and Tropaeolum were studied with the internode sections of the host material. For comparison, respirations of gall tissue were also undertaken, the gall tumours used being developed on host plants by inoculating the plant pathogen—*Ag. tumefaciens*—in the usual way. These respiration experiments were done without addition of any substrate and also with addition of various substrates, both in presence and absence of oxygen, to indicate oxygen consumption and CO_2 evolution under aerobic and anaerobic conditions. In order to study the change in respiratory behaviour of the host tissue particularly during the gall initiation period, i.e., 3–4 days after inoculation, Tropaeolum plants were inoculated with the causal organism and possible variation in R.Q. was studied after every 24 hrs. period for five days. The inoculated and the uninoculated portions of the plant were used, in parallel experiments in order to compare the behaviour of normal and infected tissue. There is an indication of increase in oxygen consumption during the initiation period, but this has to be finally confirmed.

C.1.1.4. *Phosphorus metabolism.* In order to study the Phosphorus picture in normal and gall tissue Bryophyllum and Hollyhock plants were taken as the test materials. The method of fractionation and the method of analysis of the fractionated portions have been standardised using chemical methods, paper chromatography and paper electrophoresis. Special emphasis is being given to the Barium soluble—alcohol soluble fraction which is generally discarded. This fraction, in case of plants, contains 10% to 30–40% of total organic phosphorus. Further emphasis is being given to study the way the bases—Adenylic acid, Guanylic acid, Uridylic acid, Cytidylic acid and Thymidylic acid—recently reported to be occurring in TCA soluble fraction as the bases, are distributed in the various fractions. Using known substances added to the plant extract it was found that fractionation was incomplete as these were detected in both Ba-soluble and Ba-insoluble fractions. After extracting the plant tissue with TCA, the residue was utilized for nucleic acid estimation. Use of radioactive phosphorus will be made in the study of phosphorus metabolism of normal and gall tissue during the current year.

C.1.1.5. *Polysaccharide from Normal and Gall tissue.* Importance of polysaccharide in pathological growth is well recognised by the workers in the field of human diseases including animal cancer. In order to find out whether this has any role in the formation of crown gall tissue, experiments were undertaken to isolate and identify the polysaccharide from the host plants—Hollyhock, Bryophyllum, Tropaeolum, & Marigold. So far two fractions, one insoluble in 50% alcohol and another insoluble in 80% alcohol have been worked out on qualitative basis using cold distilled water, hot distilled water (100°C...6 hrs.), 4% NaOH (100 C...6 hrs.), 45% Phenol, 10% TCA and 4% Acetic acid to extract the material primarily followed by extraction with ether. The polysaccharide seems to be a mixture of at least two distinct polysaccharides, one a polysaccharide and the other a protein-polysaccharide complex. Further work may reveal one more simple polysaccharide having only two sugar residues. The polysaccharide on hydrolysis liberates at least 7 monosaccharides and a residue. No uronic acid has been detected so far. Attempts are being made to separate the polysaccharide complex by using the method of paper electrophoresis. Preliminary experiments have shown some promising results. Quantitative analysis of these two fractions isolated both from normal tissue and gall tissue by extraction method as described before is in progress. So far no colour reagent has been found to be useful to detect the polysaccharide. Attempts are also been made to identify two sugars having R_f value more than that of Rhamnose, Rhamnose being the fastest moving common sugar.

C.1.2. *Studies on the metabolism of Blue green algae*

C.1.2.1. *Utilisation of different C^{14} labelled compounds for nucleic acid and polysaccharide syntheses in Nostoc muscorum.* Studies on nucleic acids of Nostoc muscorum were continued. Different C^{14} -labelled compounds *e.g.*, $NaHC^{14}O_3$, $HC^{14}OONa$, $C^{14}H_3COONa$ and $CH_3C^{14}OONa$ were used to study the metabolism of purine and sugar moieties of nucleic acid. It has been found that all these compounds are utilised for RNA, DNA_I and DNA_{II} synthesis. While formate appears to be the best source for the synthesis of nucleic acids, the bicarbonate-carbon is utilised at the highest rate during the early periods of incubation. Though DNA_I and DNA_{II} are present in equal amounts DNA_I has always been found to accumulate much more activities than DNA_{II} . The incorporation of C^{14} into RNA is much less than that in DNA_I . Much of the activity due to C^{14} in the nucleic acids is due to the sugar moiety. With formate— C^{14} it has been noticed that in RNA about 30% of the activity is recorded in guanine in less than half an hour, followed by a decrease with time. The percent total activity found in adenine is half of that in guanine in the initial stages but increases later. The adenine and guanine of DNA_{II} incorporate much less activity. With $NaHC^{14}O_3$ purines accumulate less activity than that with formate— C^{14} . In the purine bases of RNA, when the percent total activity in guanine decreases, that in adenine increases. In DNA_{II} a similar correlation is observed. Incorporation of carboxyl carbon of acetate into the purine bases of both DNA_{II} and RNA has been found to increase with time. The methyl carbon, however, is utilised at a much slower rate for purine synthesis; in case of DNA_{II} more than one hour being required for its incorporation into the purines. In DNA_{II} more activity has been detected in guanine than in adenine; in

RNA reverse is the case. In DNA₁ with all the C¹⁴-labelled substrates used, the activity in the individual bases is not detectable on the radioautograms. DNA in *Nostoc muscorum* is not only heterogeneous in solubility and molar constitution but also in their prior metabolic pattern.

C.1.2.2. *Nucleoproteins in Nostoc muscorum.* The nucleoproteins associated with RNA and DNA have been found to contain usually 10–15 amino acids. The amino acid composition of *Nostoc*-nucleoprotein appears to be similar to that recorded for other tissues. The amino acids detected are : aspartic acid, glutamic acid, cystine, serine, glycine, threonine, lysine, alanine, tyrosine, arginine, valine, methionine, leucine, phenylalanine and proline. The C¹⁴-labelled compounds NaHC¹⁴O₃, HC¹⁴OONa, CH₃C¹⁴OONa and C¹⁴H₃COONa are utilised rapidly for the synthesis of deoxyribo and ribo-nucleoproteins. Except in the case of formate-C¹⁴, DNA-P accumulates much more activity than that in RNP. Among the individual amino acids of the nucleoprotein-C¹⁴ hydrolysates, as revealed on radioautograms, the amino acids which have usually been found to experience large quantitative changes are : aspartic acid, glutamic acid, valine, leucine and phenylalanine. Apart from these amino acids three ninhydrin negative compounds have been detected only when acetate-1-C¹⁴ and formate-C¹⁴ are supplied.

C.1.2.3. *Polysaccharide in Nostoc muscorum.* The polysaccharide of *Nostoc muscorum* has previously been reported. Increasing amounts of this polysaccharide are synthesised with increase in time. This increase in polysaccharide content is also associated with an increase in DAN II fraction. When NaHC¹⁴O₃ is used as substrate the maximum incorporation of C¹⁴ is reached at 4 hrs. and it decreases afterwards. In the case of HC¹⁴OONa there is a steady increase of incorporation of C¹⁴ in the polysaccharide fraction throughout the experimental period, the rate of incorporation being small initially. When methyl or carboxyl labelled acetate is used the nature of the curve is found to be similar in both the cases, so far as the total incorporation of C¹⁴ is concerned *i.e.*, upto 2 hrs. there is an increase and after that it becomes more or less steady. Most of the activity has been detected in galactose and glucose when NaHC¹⁴O₃ and HC¹⁴OONa are used as substrates. In the case of acetate, both methyl and carboxyl labelled, most of the activity has been recorded in an unknown compound which was designated as U_{III}. But among the identified sugars, galactose and glucose recorded the highest activity. With acetate-2-C¹⁴ it is observed that at the initial stage the C¹⁴ is incorporated in glucose and galactose first and then to other pentose sugars. Same is the result with formate. With NaHC¹⁴O₃ and acetate-1-C¹⁴ all the sugars are tagged within ½ hr. except rhamnose in the later case. In all the experiments galactose records a higher activity than glucose at the initial stage; among the pentoses, arabinose. It has been observed that with formate as the substrate label appears at a later stage in ribose than that in arabinose or xylose. In the unknown sugars (U_I and U_{II}) label appears only when NaHC¹⁴O₃ is used within the experimental period. At least up to 6 hrs, there is no activity in those unknown sugars and rhamnose when formate-C¹⁴ and acetate, both carboxyl and methyl labelled, are used.

C.1.2.4. *Phycocyanin synthesis and nucleic acids.* Phycocyanin has been extracted from *Nostoc muscorum* and purified by column chromatography. After hydrolysis ten

amino acids have been detected. As phycocyanin is a tetrapyrrole attached with a globulin type of protein, it is reasonably expected that synthesis of phycocyanin may be associated with nucleic acid synthesis. This possibility is now being explored, by using the enzymes ribo and deoxyribo-nuclease and tracer technique.

G.1.3. *Plant mitochondria*

G.1.3.1. In the last year's report some preliminary observations on the respiration of particulate bodies "mitochondria" were recorded. During the period under review, the scope of the work was extended to the study of the relative distribution of the mitochondrial respiratory activity in roots and aerial portions of plants, mung (*Phaseolus aureus*) & maize (*Zea mays*) seedlings being used as typical representative of dicot and monocot families.

The method of preparation of particulate bodies is the same as described earlier. In brief, it consists of growing the seedlings in the dark to reduce the green chloroplast content and then separating the particular tissue by excision. The tissue was homogenised with 6 times its weight of 0.5 M Sucrose solution containing 0.1 M phosphate buffer pH 7.4 in a high speed homogeniser and the homogenate strained through two layers of cambric to free it from cell debris. The filtrate was centrifuged at 500 x g for 5 minutes at 0°C. The residue discarded and the supernatant centrifuged at 15,000 x g for 15 minutes at 0°C. The sediment contained the particulate bodies and was washed by suspension in sucrose-phosphate twice or thrice.

Oxygen consumption by these particulate preparations in presence of different intermediates of the Krebs Tricarboxylic acid cycle as substrate, was measured in Warburg respirometer at 32.5°C and μl of oxygen consumed in one hour per mg Nitrogen ($\text{QO}_2(\text{N})$) of the preparation was taken as the index of respiratory activity. In this series of studies, when the relative distribution of the particulate enzyme system was surveyed only citrate, succinate and malate were used as respiratory substrates.

It was observed that roots of both maize and mung are good sources of fairly active mitochondrial preparation. Moreover, it is to be observed that $\text{QO}_2(\text{N})$ values is higher with succinate as substrate than with either of the two others.

However in these experiments the result suffered from two drawbacks. Firstly, the preparation possessed a significantly high rate of endogenous oxygen consumption which amounted to nearly 60% of the oxygen consumption in presence of succinate. Secondly, the rate of respiration was generally found not to maintain a linear relation with time, but gradually increased in a more or less logarithmic relation.

The high endogenous activity, however, could be reduced substantially by washing the sedimented particulate bodies with 0.25 M KCl solution in ice cold Potter Elvehjem homogeniser followed by centrifugation at 15,000 x g for 15 minutes. In this method two washings of the particulate bodies reduced the rate of endogenous oxygen consumption to about 30% of that in presence of succinate. Further washing with KCl did not, however, reduce the endogenous rate any further. Washing with 0.5 M sucrose solution or 0.5 M

sucrose solution containing 0.01 M Ethylene diamine tetracetate (Versene) in the Potter Elvehjem homogeniser did not reduce the endogenous activity to any satisfactory extent.

Attempts are being made to elucidate the reason of the logarithmic rate of oxygen consumption of the preparation.

C.1.4. *Tracer studies on the phosphorus metabolism of higher plants using radioactive isotope P^{32} .*

In an earlier report from this laboratory (Report of the Bose Institute for the year 1954-55, page 35) results of experiments on the incorporation of P^{32} into various intermediates of glycolysis and some nucleotides were reported. The setting up of the new air conditioned enzyme-laboratory equipped with refrigerator centrifuge in the early months of the period under review provided the necessary conditions to extend the scope of application P^{32} in the study of phosphorus metabolism in higher plants, and a detailed study of certain aspects of phosphorus metabolism in higher plants using P^{32} was undertaken. However, the present study was restricted to the turnover of P^{32} in the intermediates of the glycolytic and pentose-phosphate pathways, in which the phospho-esters of monosaccharides are involved.

As test material various parts of mung bean seedling and avena seedling were used. The seeds were germinated under aseptic condition. Different tissues of 5-day old seedlings were collected in ice cold Tris trihydroxymethyl amino methane (TRIS) buffer pH 7.05 and kept in ice till they were used in experiments.

The plant materials thus collected were surface dried by soaking over filter paper and 2 gm. of fresh material was suspended in 4 ml of TRIS buffer at 25°C. To this the requisite quantity of stock $Na_2HP^{32}O_4$ solution was added to provide 100 μc of P^{32} in each case. In experiments where effects of some inhibitor or accelerator were studied, the requisite volume of the solution to provide the desired concentration of the agent was added and the volume made up to 3.0 ml. The system was incubated in the dark for a period of 3 hours except in the experiments in which the nature of incorporation of P^{32} with time was studied. In later cases the incubation was for the desired period of time. After incubation the plant materials were freed from adhering inorganic phosphorus by thorough washing in running water and the phospho-compounds extracted in cold trichloroacetic acid solution by repeated grinding and centrifugation at 2°C. From the combined extract the phospho-compounds were isolated as Barium salts and fractionated into the conventional Barium-insoluble and Barium-soluble alcohol-insoluble fractions which contain all the phospho-compounds under investigation. No attempt was made to study the acid-insoluble phospho-compounds, or the Barium-soluble alcohol-soluble compounds.

The Barium salts thus obtained were decomposed into soluble sodium salts by treatment with sodium sulphate and this solution of sodium salt of the esters were resolved by the method of paper chromatography. The radio-active spots were located by radioautography and the activity in the various compounds were determined by counting the activity of the corresponding spot on the paperchromatogram under a thin window Geiger counter. From the counts, the relative distributions of P^{32} activity in the different compounds were calculated.

In whole mung bean seedling the total incorporation of P^{32} in both the Barium insoluble and Ba-soluble, alcohol-insoluble fractions increased with time up to 3 hours after which it remained steady. Of the three tissues of mung studied, namely, root, hypocotyl, and cotyledon, weight for weight, the cotyledon was found to incorporate the highest activity. Normally, in root and cotyledon tissue, it is the intermediates of the glycolytic pathway which imbibe the major part of the activity, though a significant activity is discernible in 6-phospho-gluconate. In hypocotyl tissue, however, the activity of 6-phospho gluconate is significantly high.

In oat, of the three tissues tested namely, roots, coleoptile and primary leaves largest incorporation takes place in root tissue. Again, in root a considerably larger number of compounds including some of the intermediates of the pentose phosphate pathway imbibe the activity.

On studying the effect of fluoride on the incorporation of P^{32} into the phospho-intermediates in the different tissues it was observed that primarily fluoride inhibited the rate of total incorporation of P^{32} by about 40%. Considering the relative distribution of the incorporated P^{32} into various compounds, the root tissue revealed an interesting picture. In this case there was a significant gain in radioactivity in 6-phosphogluconate and sedulose-7-phosphate, as also a high increase in activity in 3-phosphoglyceric acid in the Barium insoluble fraction and also a significant gain in activity in Glucose-6-phosphate, Fructose-6-phosphate and Ribose-5-phosphate, in the Barium-soluble alcohol-insoluble fraction. Another significant effect of fluoride in root tissue is that there was hardly any activity accumulating in Adenosine triphosphate and Adenosine diphosphate.

In hypocotyl tissue, however, the effect of fluoride is not exactly the same, though there is some gain in the proportion of activity in 3-phosphoglyceric acid and in Ribose-5-phosphate. There is no noticeable rise in activity in 6-phosphogluconate or sedulose-7-phosphate, although ATP seems to have lost all radioactivity.

In root and coleoptile tissues of oats, fluoride treatment produced almost the same effect as is obtained in the root tissue of mung.

The gain in activity in G-6-P, 6-PG, S-7-P and R-5-P, the important intermediates of the pentose phosphate pathway, on fluoride treatment particularly in root tissue suggest an enhanced metabolism of phosphorus *via* the pentose phosphate pathway. The considerable rise in activity in 3-PGA is consistent with the well known property of fluoride to inhibit 'enolase', the enzyme system bringing about the conversion of 2-PGA to 2-phospho-enol pyruvate and at the same time suggests some depression of phosphoglyceric mutase system. The loss of activity in ATP may suggest a depression of triosephosphate dehydrogenase. Although fluoride is considered to be a specific inhibitor of enolase activity, its effects of other enzyme systems, particularly, the Mg^{++} containing ones, have been suggested from time to time. Phospho-glyceric kinase, a Mg^{++} containing enzyme is closely associated with triosephosphate dehydrogenase and is likely to be inhibited by fluoride. The loss of activity in ATP is consistent with this presumption. However, the direct inhibition of triosephosphate dehydrogenase by specific inhibitors like iodoacetate

is to be studied before a satisfactory answer to this question could be provided. With this in view, experiments were conducted in which the effects of iodoacetate on incorporation of P^{32} in mung bean root tissue were studied. At the time of writing this report the radio-autographs are ready. The relative distribution of P^{32} in the different compounds is still to be calculated.

Recently it has been suggested that if reactions of the Krebs T.C.A. cycle is suppressed or curtailed more glucose is diverted towards the pentose phosphate pathway. The present observation tends to lend support to this view by demonstrating that when conversion of 3-PGA to pyruvate is blocked, which would lead to a possible curtailment of Krebs cycle, the P^{32} metabolism is also indicated in favour of the pentose phosphate pathway. However, direct test of this hypothesis could be provided by a study of the effect of specific inhibitors of Krebs cycle like fluoroacetate on phosphorus metabolism and experiments with this aim in view are in progress.

C. 2. Plant Physiology

C.2.1. *Autogenic response of Mimosa leaf*

A detailed account about the autogenic response in *Mimosa* was included in the last year's report. It was stated that the leaves in their young stages only exhibit this characteristic behaviour. The highest number of such responses occurring in a leaf, as stated in that report, was six in twenty-four hours. It was found later that the frequency of responses can far exceed the number in some specimens; it may be as many as twenty or even more in twenty-four hours.

As no antecedent cause could be attributed to the randomly occurring responses at different times of day and night it was assumed that it might be due to random impact of Cosmic Ray particles to the pulvinus of the responding leaf. In order to test the validity of this assumption a Beta Ray source was placed near the leaf. But the β -particles emitted from it were not found to influence, in any way, the normal behaviour of the leaf.

Further continuation of the work shows that the autogenic activity is much diminished or totally disappears in Winter when the growth of the plant becomes very sluggish, and also at the time of Summer when the dry heat prevails. When a twig is separated from the plant and kept alive for some days the young leaf on it does not exhibit any autogenic behaviour. Similarly when the sub-petioles of the young leaf are discarded and only the petiole remains attached to the plant the autogenic activity of the pulvinus disappears.

Removal of the top bud also annuls this autogenic activity in the young leaf. Indications of partial revival of autogenic behaviour in the leaf under such debudded condition have been obtained by the application of .01% indole acetic acid in lanoline paste on the cut surface. This shows that plant hormone has some relation with the autogenic behaviour of the leaf. But how it is correlated with the phenomenon is not clearly understood. It may be that its influence is only indirect. It is conceivable that an adequate supply of hormone in the leaf at its young stage, is essential for the process of its development.

And since the autogenic excitatory impulses appear only in the young leaf the cause may be assigned to some internal changes occurring at the time of its vigorous development.

C.2.2. *Excitatory response of Mimosa in a condition of drought*

That the pulvinus loses water in its contractile movement and regains water for recovery, are definitely established. J. C. Bose has shown in an experiment that in a condition of drought the leaves gradually sag down due to the fall of turgor pressure in the pulvinus. The leaves in such condition, do, however, respond to stimulation though they take more time for recovery, in comparison to the normal. It shows that when the turgor level is low in the pulvinus it still responds to stimulation undergoing further loss of water in response, and regaining it in recovery. It was proposed to study how long and to what extent, the pulvinus can maintain its responding capacity in a continuous drought condition. It could be most suitably studied in detached specimens.

A stem piece with a leaf was detached from the plant. In order to slow down the rate of water loss due to evaporation the sub-petioles were discarded. Thus the experiment was performed with the petiole stump attached to the stem piece. Such a piece was first allowed to absorb water till it fully recovered and became turgid. It was then taken out of water and the adhering water thoroughly wiped out, with dry cotton, before attaching it to the recorder, for recording the response and recovery time of the pulvinus by application of electric shock at intervals of twenty minutes. An identically similar specimen was kept on the pan of a sensitive balance to observe the rate of water loss from the tissue.

The record shows that the plant in that drought condition could maintain its responsive capacity for about three hours. The amplitude of response, however, became gradually diminished till there was no response at all. The record shows that the petiole had come to rest at recovery, after each response, at a level lower than the previous one. Finally the petiole became stand-still at its lowest position indicating that the pulvinus could not contract further with excitation.

The nature of the rate of water loss was understood from the weight of the specimen in the balance taken every twenty minutes. The total moisture of such specimens, as determined by drying them in steam chamber, was found to be about 75% of its weight. The normal water loss of such specimen, when exposed to air, was about 20% in the first hour and the total loss at the end of three hours was about 45%. The rate of loss progressively decreased with time.

This experiment shows that the leaf retains its responsive capacity even when it has sagged under heavy deficit of water in the plant. The recovery of the leaf, though partial after each response, indicates that the pulvinus is capable of absorbing water for its expansion from the adjoining tissues where the turgor pressure is already much reduced.

C.2.3. *Diurnal diametric changes of the pulvinus of mimosa*

The characteristic diurnal movement of Mimosa leaf with its spasmodic evening fall has been discussed in previous reports. With the idea of further inquiry into the subject

it was proposed to study the diametric changes of the pulvinus, independent of the movement of the petiole.

A Plant-Sphygmograph devised by J. C. Bose was suitably modified for the experiment. The stem and the petiole being fixed rigidly the pulvinus was placed between knife-edge and spring-lever of the Sphygmograph. The spring-lever was conveniently attached with the recording lever of a twenty-four hour recorder.

The diurnal record of the changes of the pulvinus seemed to be a true replica of the diurnal record of the petiolar movement. This shows that the changes of the position of the petiole throughout day and night are entirely regulated by the expansion and contraction of the pulvinar organ. The explanation of Pfeffer that the spasmodic evening fall is brought about by the increased mechanical moment of the sub-petiole, is not tenable. Because in the present case, the petiole was rigidly fixed, yet the pulvinus had undergone great contraction in the usual hour of the evening fall of the leaf. This sufficiently proves that the evening fall of the leaf is caused by the contraction of the pulvinus occurring at the time.

When the leaf had been excited at intervals of one hour there was marked contraction of the pulvinus with recovery within usual time. The hourly excitation did not affect its characteristic evening contraction. The amplitude of the spasmodic evening contraction far surpassed the amplitude of the usual noon-time responsive contraction of the pulvinus. It is peculiar that when the maximum evening contraction has occurred it is yet capable of further contraction due to stimulus; the amplitude of such response is, however, comparatively smaller than that of the noon-time response. Further the recovery of the responsive movement during the evening contractile period is such that it maintains the continuity of the curve of the evening contraction. This phenomenon was also observed during the study of the petiolar movement.

Since the pulvinus is capable of further response when the maximum evening contraction had occurred, it indicates that the loss of hydrostatic pressure in the pulvinus resulting in its contraction in the evening, does not take place uniformly in all of its tissues. It may be that the evening contraction of the pulvinus is brought about mainly by the reduction of pressure in the intercellular spaces, the motor cells remaining less affected.

The diurnal diametric changes of the stem was also recorded in order to understand whether the evening fall of the leaf has any relation with the turgidity condition of the stem. Record shows that the stem undergoes contraction throughout the day, and expands at night. The day contraction is, no doubt, due to the fall of turgidity by increased transpiration. The contraction starts from 8 in the morning and continues up to 4-5 in the evening. This will show that the turgidity of the stem is minimum at the time when the evening fall of the leaf starts.

C.2.4. *Induced rhythmicity in the leaf of Mimosa*

It has been observed that when the Mimosa plant is subjected to prolonged high-temperature condition the normal behaviour of the leaf is changed. In place of its normal nyctinastic movement the leaf acquires a rhythmic behaviour, exhibiting five to seven conti-

nuous up and down oscillations in twenty-four hours. Its excitability is also lost in that condition. This was observed when the plant was confined in the thermostatic chamber adjusted to the maximum day-temperature at 30°C. This temperature is not at all high for the plant when it is normally exposed to it for a certain part of the day. But when such temperature is made constant it becomes detrimental to the plant. In the thermostatic chamber the plant seemed to be deteriorated within three to four days; the leaves start yellowing from bottom upward. The normal nyctinastic behaviour continues for the first day. After that it assumes the rhythmic character and continues for about two days, finally becoming stand-still. This rhythmic phenomenon was also observed in the records of some plants when the seasonal temperature was very high.

C.2.5. *Loss of turgor in the pulvinus of Mimosa pudica due to excitatory contraction*

A short note on the above work has been published in 'Science & Culture', vol. 22, July, 1956.

The detailed paper has been made ready for publication elsewhere.

C. 3. Cytology

C.3.1. Work on sensitive plants was carried out as continuation of last year's and covered histochemical, cytological studies. The field was narrowed down to observing the motile cell, which was found to be of the same basic type in all the range of plants studied. *Mimosa pudica* was taken as type specimen, other plants being used for comparison.

C.3.1.1. *Cytological studies*: Previous observations on mitochondria and plastids were repeated and confirmed. In order to study the chromosome complements of sensitive plants many of which are unreported, attempts were made to germinate seeds for obtaining root tips. Viability was limited in most cases from 3 to 4% if left to grow in sawdust. Temperature treatment helped to overcome dormancy, in first chilling the seeds then soaking them in warm water till they swelled, then transferring them to wet filterpaper to germinate. Root tips were fixed on the 2nd day of emergence. By this method, viability was stepped up to 50%. Decapitated seedlings were not thrown away, but transferred to pots where they grew into healthy disease free plants with a high degree of sensitivity. A number of fixing fluids were tried. One combination with a low concentration of Coumarin gave best results with well fixed and well scattered chromosomes.

C.3.1.2. *Microchemical studies*. Tests were performed mainly on the tannin inclusion of the cell. Some were directed to determining the nature of the cell wall.

(a) *Carotene*. In previous years, Institute workers had shown that carotene was present in the active zone of *Mimosa pudica*. Attempts were made to locate that carotene.

Whole leaves of *M. pudica* and *Desmodium gyrans* were treated with Steiger's alcohol alkali mixture in the dark, then the decolorized tissues were dried and treated with sulphuric acid. The gradual appearance and increase in quantity of bluegreen crystals in the cells indicated the presence of carotene.

In both specimens, carotene was present in the leaf blades but totally absent in all orders of pulvini. Heaviest concentration was found in *M. pudica* and the tip axes of the small motile blades of *Desmodium gyrans* which in the case of the latter corresponds to the area of concentration of such other matter as calcium oxalate crystals and a Feulgen positive cell content.

b) *Protein*. It was previously suggested that in the tannin inclusion, protein was possibly present. This year's results strengthened that view.

Positive results were obtained with the *Romeiu reaction for tryptophane protein*. A red colour reaction is expected. In contrast to the light brown inclusions of formalin fixed control, in treated material they turned a deep reddish brown.

Bensley's modification of *Millon's reaction for tryptophane protein* makes the innovation of using chilled reagent instead of warmed, with superior results. Distortion of tissues is eliminated. In place of a few minutes reaction after which the section becomes swollen and unrecognizable, here the complete red colour of the positive reaction came after 3 hrs. of treatment, the time no doubt being dependent on the material.

c) *Cellulose*. Fresh hand sections of main pulvinus of *M. pudica* were treated.

i) The following, among the dyes listed by Johanson as being specific for cellulose, have stained cell walls :

Acid Fuchsin
Bismarck brown
Congo red
Delafield's Haematoxylin
Fast Green
Light Green

Of the nonspecific dyes, walls have stained with Safranin, Gentian violet, crystal violet and many vital dyes.

- ii) Mangin's test with iodine and phosphoric acid gave a blue colour (positive) although the colour was weak.
- iii) Mangelin's test with iodine and calcium chloride also gave the positive violet colour, though the colour was weak.
- iv) Johansen distinguished true cellulose from hemicellulose by determining whether walls dissolve with HCl of sp. gr. 1.19. Walls when treated do not dissolve showing they are of true cellulose.
- v) With Kragg's test for distinguishing between oxy and hydroxy-cellulose, a faint pink colour of the walls, in place of the deep crimson for hydroxy-cellulose, was obtained.
- vi) Chlor-zinc-iodine gave a faint violet reaction of the walls.

In all cases, walls of upper and lower cortex reacted similarly.

Tests nos (ii, iii, v and vi) serve to support Weintraub's point that the cellulose in the walls is masked by an impregnating substance, giving thereby in all cases a positive, but faint reaction.

d) *Sugar*. In previous years starch tests had been attempted yielding conflicting results. *Mimosa* cells contain some very specialized bodies which are totally unlike any found in other vegetative cells. As the cells carry chlorophyll it appeared possible that cells carried carbohydrates in the form of sugar. With Molisch's sugar test, involving the use of thymol and sulphuric acid, a general red (positive) colour is obtained, which latter streams out of the section, but the source cannot be located.

e) *Starch*. The methods outlined by Glick were followed.

i) With picric acid and crystal violet, starch grains are expected to specifically take a violet colour. However, the following structures stain violet, Some of the mitochondria like bodies, bunched bodies in the endodermis, 'bubbles' in tannin inclusions, anthocyanin bodies in the epidermis and lignin. Bodies in the cortex stain less deeply than in the endodermal layer.

ii) With Milovilov's technique for distinguishing between starch grains and mitochondria, inconclusive results were obtained.

Dilute iodine confirmed the results found in (a). Some of the cortical bodies stain a barely visible light blue, while in the endodermal layer they are punched and have a blue black reaction.

These results give rise to a number of considerations. Starch is definitely present and is normal, in heavy concentration in the endodermal layer or starch sheath. The 'bunched' appearance may be due to the compound nature of the grains.

But outside the starch sheath, some 'bodies' give the starch reaction although so faintly as to be barely visible. These bodies resemble in appearance other bodies which react for mitochondria. They are definitely not starch grains. They are coloured green but neither are they chloroplastids, as concluded after careful consideration against currently published electron microscope studies of the same. Apparently they are plastids, carrying chlorophyll, without the structure of the chloroplast, and they also carry a certain amount of starch, giving thereby barely visible positive reaction. The line between plastids and mitochondria is not finely drawn and their origin is still not very well known. In *Mimosa* it would appear that mitochondria and plastids grade into each other and both are somewhat modified from the usual type of these cytoplasmic inclusions found in the nonactive vegetative cell.

VI. Sections were examined under polarized light to determine whether these starch carrying bodies were grains or not. Polaroid plates were not suitable and observations will be repeated.

C.3.2. *Cytological studies on the division figures of nuclei suspended in the endospermal milk of some Palmae.*

The work under this programme was a continuation of the problem started earlier at the Institute. Free floating nuclei occurring naturally in the endospermal milk of the coconut were found to undergo somatic division. Attempts were made to see whether a

dividing figure would continue with the mitotic process when mounted on a slide. Generally in this state, fresh mounts tend to become infected with bacteria, nuclei break up and mitochondria stop moving. After many trials finally success was achieved with hanging drop mounts, made and sealed under sterile conditions and observed under controlled conditions of light and temperature. Figures at prophase were actually directly observed to progress from metaphase, to anaphase to telophase. They were clearly visible under high power. Pressure on the coverslip from the objective precluded oil immersion studies. Many records on actual division were made, details of the process and the time taken to do so noted. From metaphase to the lying down of the cleavage plate requires 20 mts. but after that no further changes are observed to take place. These sealed moments stay fresh for up to 4 hrs only, after which all nuclei go into a resting condition, therefore observation is limited by this time factor. Attempts will be made to overcome this.

Fruit picked that very day are ideal for observation. They deteriorate if kept for a few days at room temperature. However they may be stored at cold temperature when division stops but the fruit remains fresh. A high frequency of division can be induced by placing the chilled fruit for 3-4 hours in the sun and then cutting it open for observation.

The jellylike endosperm was fixed in acetic alcohol, treated in bulk by the Feugenl technique, stained in mass, then teased out in scraps and permanently mounted. Brilliantly stained plates were thus obtained. Paraffin mounts are not suitable due to the amorphous nature of the material and lack of orientation in tissue organization.

With the aid of a Leica camera, Leitz attachment apparatus, and Leit 2 Ortholux microscope, photographic records were frequently made of the stages noted above and other phenomena. Brilliant prints with clear details are obtainable only under high power, with freshly mounted material and without benefit of fixation or staining.

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C. RADIATION AND CYTOGENETICS, PLANT BREEDING, ANATOMY AND WEED CONTROL

C. 4. RADIATION AND CYTOGENETICS

C.4.1. *Effects of X-rays and beta rays in Til (Sesamum)*

X-RAYS

During the year under report, detailed investigations were conducted on the oil content, composition of the oil, yield, earliness etc., of the irradiated progenies and mutants of the previous year, in addition to studying the effects of fresh irradiations.

The season was unfavourable for the growth of the sesamum plants due to adverse cyclonic weather accompanied by heavy rains, resulting in comparatively lower yields.

C.4.1.1. *Oil content and quality of the oil in white flowered and small seeded mutants*

The oil contents of the *white flowered mutant* isolated in the X_3 generation from the 50 m.a.H. treatment in 1952, and the *small seeded mutant* isolated in the X_4 generation from the 36 m.a.H. treatment in 1953, from *S. orientale* type 16, have been analysed statistically and the results have been included in Table 1.

TABLE 1

Mutants and Control	Mean per cent $\pm$ S.E.	Mean per cent $\pm$ S.E. over control
Control	41.49 $\pm$ 0.51	100.00 $\pm$ 1.23
White flowered mutant	44.06 $\pm$ 0.51	106.18 $\pm$ 1.23
Small seeded mutant	52.10 $\pm$ 0.51	125.56 $\pm$ 1.23

It will be seen from the Table 1 that the white flowered mutant gives nearly 6% and the small seeded mutant nearly 26% more yield of oil, over the control. The chemical constitution of the oil in the X_6 generation is given in Tables 2 and 3.

TABLE 2

CHARACTERISTICS OF OIL

Sample	Colour by Lovibond scale	Refractive Index $N_D^{20^\circ C}$	Saponification value	Iodine Value	% Non-Sap.
Control	Y = 1.6	1.4737	192.2	108.0	1.66
	R = 0.4				
White flowered mutant	Y = 1.5	1.4738	192.0	109.2	1.92
	R = 0.3				

TABLE 3

COMPOSITION OF MIXED FATTY ACIDS

Sample	% Saturated acids	% Oleic acids	% Lino-leic acids
Control	14.1	44.5	41.4
White-flowered mutant	14.3	47.4	38.3

It will be seen from the above tables (2 and 3) that there are no significant differences in the colour, Refractive Index, Sap value, Iodine value, percentage Non-Sap and mixed fatty acids, of the oils extracted from the control (*Sesamum* type 16) and its white flowered mutant.

TABLE 4

PEROXIDE VALUE

Sample	Freshly Extracted Oil	Oil kept for a month
Control	6.6	21.5
White-flowered mutant	6.4	10.4

The freshly extracted oil of the white flowered mutant does not show marked differences in its peroxide value from the control (Table 4), which is 6.4 and 6.6 respectively. But when the oils were kept for one month, and then analysed, it was found that the peroxide value of the mutant was 10.4, as against the control having 21.5. Therefore, it appears that the oil of the mutant has better keeping qualities.

TABLE 5

CHARACTERISTICS OF OIL

Sample	Colour by Lovibond scale	Refractive Index $N_D^{20^\circ\text{C}}$	Saponification Value	Iodine Value	% Non-Sap.
Control	Y = 1.4 R = 0.3	1.4736	191.6	105.7	1.86
Small seeded mutant	Y = 1.5 R = 0.3	1.4733	192.4	102.0	1.68

TABLE 6

MIXED FATTY ACIDS

Sample	% Saturated acids	% Oleic acid	% Lino-leic acid
Control	14.8	45.2	40.0
Small seeded mutant	15.0	45.5	39.5

Like white flowered mutant, the oil extracted from the small seeded mutant also, does not show any marked difference in the colour, Refractive Index, Sap value, Iodine value, percentage Non Sap (Table 5) and mixed fatty acids, from its control (Table 6).

TABLE 7
PEROXIDE VALUE

Sample	Freshly-extracted Oil	Oil kept for a month
Control	6.5	20.0
Small-seeded mutant	2.2	9.5

The freshly extracted oil of the small seeded mutant with a peroxide value 2.2, has much better keeping quality than that of control with peroxide value 6.5. After a month, although there is an increase in the peroxide values of these oils, the oil of the small seeded mutant with its peroxide value 9.5 shows better keeping quality than oil of the control with its peroxide value of 20.0 (Table 7).

Thus these two morphological mutants, (white flowered and small seeded, of *Sesamum* type 16), with their higher oil content of 6% and 26% in the X_6 generation and better keeping qualities of the oil appear to be useful from the economic points of view.

C.4.1.2. Statistical analysis of the fruit yield in successive generations of the irradiated progenies.

In the following tables, while in the X_1 generation the mean yields of the individual plants have been considered, in the subsequent generations, the mean of the progenies of best plants have been taken into account. In all the tables, the Standard Error and Critical Difference at 5% level have been calculated.

Table 8 gives the mean number of fruits in the treatments and controls for six generations (1950-55), in *Sesamum* type No. 12,

TABLE 8

Type and Locality	Generation Treatment and Control	X_1 (1950)		X_2 (1951)		X_3 (1952)		X_4 (1953)		X_5 (1954)		X_6 (1955)	
		Mean	Per-cent of Control	Mean	Per-cent of Control	Mean	Per-cent of Control	Mean	Per-cent of Control	Mean	Per-cent of Control	Mean	Per-cent of Control
Type 12 (West Bengal)	Control	25.2	100.0	149.2	100.0	139.0	100.0	86.5	100.0	142.6	100.0	79.0	100.0
	36 m.a.H.†	12.3	48.8	119.1	79.8	149.4	107.5	82.4	95.3	155.2	108.8	162.4*	205.6
	50 m.a.H.	13.8	54.8	89.7	60.1	124.0	89.2	77.6	89.7	123.0	86.3	113.7	143.9
	S.E.	3.2	12.7	13.2	8.8	7.9	5.7	13.4	15.5	15.4	10.8	18.2	23.0
	C.D. at 5%	9.2	36.5	38.4	25.7	22.9	16.5	38.7	44.7	44.5	31.2	52.7	66.7

* Significantly better than Control at 5% level.

† The exposures expressed in m.a. H. were given with a continuously evacuated X-ray tube run at 30 K.V. and 4 m.a. current, at a target distance of 8 cms. from the tube.

It will be seen from the table that in the X_1 generation the mean number of fruits, viz., 12.3 and 13.8 in the two treatments 36 and 50 m.a.H. respectively, are lower than the control with 25.2 fruits. The mean of the progenies of the best plants in these two treatments, gave a lower yield in the X_2 generation i.e. 119.1 and 89.7 as against 149.2 of control. But in the X_3 generation, the mean of the progenies of the best plants of the X_2 generation of the 36 m.a.H. treatment, gives a higher yield i.e. 149.4 fruits and in 50 m.a.H. a lower yield i.e. 124.0 fruits as against 139.0 fruits of the control. Again in X_4 generation, the best plants in 36 and 50 m.a.H. treatments with 82.4 and 77.6 fruits respectively, give lower mean yields as against the control with 86.5 fruits. In the X_5 generation, while the selections in 36 m.a.H. give higher mean yield of 155.2 fruits than the control with 142.6 fruits, the selections in 50 m.a.H. again give lower mean yield i.e. 123.0 fruits. In X_6 generation, though the selections in 50 m.a.H. treatment give higher mean yield of 113.7 fruits as against the control with 79.0 fruits, selections in 36 m.a.H. give significant higher mean yield i.e. 162.4 fruits *which is 105.6 percent more than the control.*

Table 9 gives the mean number of fruits in treatments and controls for five generations (1950-54) in *Sesamum* type No. 16.

TABLE 9

Type and Locality	Generation Treatment and Control	X_1 (1950)		X_2 (1951)		X_3 (1952)		X_4 (1953)		X_5 (1954)	
		Mean	Per-cent of control	Mean	Per-cent of control	Mean	Per-cent of control	Mean	Per-cent of control	mean	Per-cent of control
Type 16 (W. Bengal)	Control	15.6	100.0	159.7	100.0	109.0	100.0	105.7	100.0	111.5	100.0
	36 m.a.H.	19.9	127.6	166.2	104.1	242.4*	222.4	162.1*	153.4	226.4*	203.1
	50 m.a.H.	12.8	82.1	150.7	94.4	174.0*	159.6	112.7	106.6	125.3	112.4
	S.E.	3.5	22.4	22.9	14.3	16.8	15.4	18.2	17.2	18.2	16.3
	C.D. at 5%	10.0	64.1	66.4	41.6	48.7	44.7	52.8	50.0	52.8	47.4

* Significantly better than control at 5% level.

It will be seen from the table that in the X_1 generation, while the treatment of 36 m.a.H. with mean yield of 19.9 fruits gave higher yield than the control with mean yield of 15.6 fruits, the 50 m.a.H. treatment with mean yield of 12.8 fruits, was lower than the control. In the X_2 generation, selections of the progeny of best plant in 36 m.a.H. treatment, gave higher mean yield of 166.2 fruits as against 159.7 fruits in the control. In 50 m.a.H. treatment, however, the progenies of best selections again gave lower yield of 150.7 fruits, against the control with 159.7 fruits. The best plants of these higher yielders in subsequent generations continued to give higher yield as against control, so much so that in 36 m.a.H. in the X_3 , X_4 and X_5 generations, the yield was significantly higher i.e. the mean yields of fruits were 242.4, 162.1 and 226.4 as against the respective figures of 109.0, 105.7 and 111.5 in the controls, which are 122.4, 53.4 and 103.1 percent higher than the controls.

Table 10 gives the mean number of fruits in treatments and controls for five generations (1951-55), in *Sesamum* type T.M.V. 1.

TABLE 10

Type and Locality	Generation Treatment and Control	X ₁ (1951)		X ₂ (1952)		X ₃ (1953)		X ₄ (1954)		X ₅ (1955)	
		Mean	Per- cent of con- trol	Mean	Per- cent of con- trol	Mean	Per- cent of con- trol	Mean	Per- cent of con- trol	Mean	Per- cent of con- trol
T.M.V. 1 (Madras)	Control	106.8	100.0	150.3	100.0	93.3	100.0	170.2	100.0	77.0	100.0
	36 m.a.H.	115.4	108.0	206.2	137.2	95.6	102.5	169.1	99.4	134.2*	174.3
	50 m.a.H.	130.3	122.8	240.3*	159.9	100.0	107.2	221.8	130.3	132.6*	172.2
	100 m.a.H.	155.5	145.5	202.3	134.6	98.6	105.7	151.0	88.7	110.8	143.9
	S.E.	17.6	16.5	23.1	15.4	15.3	16.4	19.9	11.7	14.8	19.2
	C.D. at 5%	50.6	47.4	66.3	44.1	43.9	47.1	57.1	33.5	42.6	55.4

* Indicates significantly better than control at 5% level.

It will be seen from the table that in all the three treatments, 36, 50 and 100 m.a.H., the mean number of fruits in the X₁ generation, were 115.4, 130.3 and 155.5 respectively, as against 106.8 of the control. In the X₂ generation, the progenies of best plants of X₁ generation, in the three treatments 36, 50 and 100 m.a.H. gave higher mean yield of 206.2, 240.3 and 202.3 fruits respectively, as against mean yield of 150.3 fruits of control. The yield in the 50 m.a.H. treatment being about 60 percent higher than the control, is highly significant. In the X₃ generation, the progenies of the selections of the X₂ of 36, 50 and 100 m.a.H. treatments, again show higher mean yield of 95.6 100.0 and 98.6 fruits respectively, as against 93.3 fruits of control. Similarly in the X₄ generation, selections of the best plant progenies of the X₃ generation of 36, 50 and 100 m.a.H. treatments, gave mean yield of 169.1, 221.8 and 151.0 fruits as against 170.2 fruits of the control. Here, only the best selection from the 50 m.a.H. had higher yield than the control. But in the X₅ generation, selections of the progenies the best plants of X₄ in 36, 50 and 100 m.a.H. treatments, had mean yields of 134.2, 132.6 and 110.8 fruits as against 77.0 fruits of control, which, in the case of 36 and 50 m.a.H. treatments, gave 74.3 and 72.2 percent higher yield respectively than the control and hence are highly significant.

Table 11 gives the mean number of fruits in treatments and controls for four generations (1952-55), in *Sesamum* type No. 10.

TABLE 11

Type and Locality	Generation Treatment and Control	X ₁ (1952)		X ₂ (1953)		X ₃ (1954)		X ₄ (1955)	
		Mean	Per cent of control	Mean	Per cent of control	Mean	Per cent of control	Mean	Percent of control
Type 10 (W. Bengal)	Control	175.0	100.0	118.3	100.0	204.8	100.0	154.2	100.0
	100 m.a.H.	216.4	123.6	138.7	116.5	179.2	87.5	229.9*	149.1
	140 m.a.H.	206.4	117.9	207.0*	175.0	161.0	78.6	187.4	121.5
	S.E.	30.1	17.2	24.4	20.6	21.0	10.3	23.2	15.0
	C.D. at 5%	87.4	49.9	70.7	59.8	60.8	29.7	67.3	43.6

* Denotes significantly higher than control at 5% level.

It will be seen from the table that in the X_1 generation, the mean yield of fruits in two treatments 100 and 140 m.a.H., is 216.4 and 206.4 respectively, as against 175.0 of control. In the X_2 generation, the progenies of the best X_1 plants of the 100 and 140 m.a.H. treatments gave higher mean yields of 137.8 and 207.0 fruits as against 118.3 fruits of control, which in the latter is 75.0 percent higher than the control and hence highly significant. In the X_3 generation, the progenies of X_2 in 100 and 140 m.a.H. treatments gave mean yields of 179.2 and 161.0 fruits as against 204.8 fruits of control. In the X_4 generation, the progenies of the best X_3 plants in 100 and 140 m.a.H. treatments, gave higher mean yields of 229.9 and 187.4 fruits respectively, as against 154.2 fruits of control which in 100 m.a.H. treatment is higher by 49.1 percent and hence highly significant.

Table 12 gives the mean number of fruits in treatments and controls for two generations (1954 and 1955), in *Sesamum* type No. 20.

TABLE 12

Type and Locality	Generation Treatment and Control	X_1 (1954)		X_2 (1955)	
		Mean	Percent of control	Mean	Percent of control
Type 20 (W. Bengal)	Control	37.6	100.0	102.8	100.0
	20 m.a.H.	44.8	119.2	138.8	135.0
	100 m.a.H.	55.0	146.3	122.1	118.8
	200 m.a.H.	47.0	125.0	153.2*	149.0
	S.E.	7.7	20.5	12.2	11.9
	C.D. at 5%	22.4	59.6	35.1	34.1

* Significantly better than control at 5% level.

It will be seen from the table that in the X_1 generation, the mean number of fruits in 20, 100 and 200 m.a.H. treatments were 44.8, 55.0 and 47.0 respectively, as against 37.6 of control. The progenies of the best X_1 plants in the X_2 generations, gave mean yields of 138.5, 122.1 and 153.2 fruits respectively, as against 102.8 of control. While in all these treatments mean yield is higher than the control, the yield in 200 m.a.H. treatment, higher by about 50.0 percent than the control, is highly significant.

C.4.1.3. General conclusions on the yield (number of fruits) data.

It can be concluded from tables that (i) the best selections giving higher yield than the control in the first generations continue to do so in subsequent generations (Table 9 type No. 16, 36 m.a.H. and Table 10 T.M.V.I., 50 m.a.H.), (ii) the best selections giving a higher yield than the control in the first generation may at any subsequent generation give lower yield than the control, only to give again a higher yield in the subsequent generations (Table 10 T.M.V.I., 36 and 100 m.a.H. and Table 11 type No. 10, 100 and 140 m.a.H.) (iii) the best selections giving lower yield than the control in the first generation may at a later generation give higher yield, which continues in the subsequent generations (Table 8, type No. 12, 36 and 50 m.a.H. and Table 9, type No. 16, 50 m.a.H.) and (iv) the selections

giving lower yield than the control in the first generation continue to do so in the subsequent generations (such selections have not been included in any of the tables mentioned above).

It is apparent then, that out of the above four categories involving the subsequent behaviour of the best plants selected in every generation, the first three include best plants which show the tendency to get stabilised for higher yield within the period of third to sixth generations. Thus the present method of selecting the best plants in the population appears to be correct, as their progenies give a higher yield ultimately. Also, in the case of single plant selection, the ancestry of the recessive or morphological mutants that are isolated, can be ascertained, together with the dosage etc.

C.4.1.4. Behaviour of the selections in the current year compared to the previous year

Table 13 gives the performance of the higher yielding plants of X_6 generation 1955, of Sesamum types No. 12 and 16, which are in the X_7 generation during the year under report. These were sown on 5/4/1956.

TABLE 13
 X_6 (1955) X_7 (1956)

Type and Locality	Control and Treatment	Selection No.	Max. No. of fruits	Selection No.	Max. No. of fruits	Weight of 1000 seeds in gms.
No. 12 (W. Bengal)	Control	A1/3/5	262	3A/5/6	49	2.00
	36 m.a.H.	A2/1/4	553	3B/3/17	126	3.70
	50 m.a.H.	F3/2/7	210	3C/5/9	80	2.70
No. 16 (W. Bengal)	Control	C4/4/3	244	3D/2/5	60	2.30
	36 m.a.H.	A5/2/1	348	1E/6/4	60	—
	"	E5/1/2	330	1E/2/8	65	2.50
	50 m.a.H.	D6/1/4	356	2F/2/16	81	3.72
	"	C6/3/4	318	3F/4/15	110	2.20

It will be seen from the above table that both in types 12 and 16, selections from the previous year continued to do well in the X_7 generation of the current year. In type 12, while the control gave 49 fruits, selections in 36 and 50 m.a.H. treatments gave 126 and 80 fruits respectively, which in the former is about $2\frac{1}{2}$ times and in the latter about $1\frac{1}{2}$ times more than the control.

1,000 seeds of these selections of 36 and 50 m.a.H. treatments, weighed 3.70 and 2.70 gms. respectively as against 2.00 gms. of control. Similarly in type No. 16, though a selection in 36 m.a.H. treatment gave 60 fruits which is the same as that of control, a selection 3F/4/15 in 50 m.a.H. treatment gave a maximum of 110 fruits. The yield of the parent selection in the previous year was also fairly good i.e. 318 fruits as against 244 of control. The 1,000 seeds of selection 3F/4/15, however, weighed 2.20 gms. which is less than the 2.30gms. of control and much less than the other two selections 1E/2/8, of 36 m.a.H. treatment, and 2F/2/16, of 50 m.a.H. treatment, weighing 2.50 and 3.72 gms. respectively. Their behaviour in the next generation will make interesting study.

Table 14 gives the performance of the selections of Sesamum type No. 10, which is in the X_4 generation during the session. This was sown on 14/4/1956. The relative yield of the X_3 generation is also given for purposes of comparison.

TABLE 14

Type and Locality	Control and Treatment	X_3 —1955		X_4 —1956	
		Selection No.	Max. No. of fruits	Selection No.	Max. No. of fruits
No. 10 (W. Bengal)	Control	A1/2/2	224	F.S./1/35	75
	140 m.a.H.	B1/3/2	198	F.S./2/43	95
	200 m.a.H.	C1/1/1	175	F.S./3/19	42
	"	C1/2/2	128	F.S./4/23	72
	"	C1/3/1	265	F.S./5/37	75
	10,000 r	D2/1/2	146	F.S./6/23	56
		D1/3/5	164	F.S./7/34	26
	12,500 r	E2/1/5	164	F.S./8/34	90

It will be seen from the table that the selections of 140 m.a.H. and 12,500 r treatments only, gave higher yield of 95 and 90 fruits respectively as against 75 of control. The parents of these selections had given low yield of 198 and 164 fruits as against 224 of control.

The selections in 200 m.a.H. and 10,000 r treatments, however, gave lesser number of fruits than the control.

Table 15 gives the performance of the selections of Sesamum, type No. 10, and T.M.V.1 from Madras, which are in the X_3 generation during the year.

TABLE 15

Type and Locality	Control and Treatment	X_2 —1955		X_3 —1956		Weight of 1000 seeds in gms.
		Selection No.	Max. No. of fruits	Selection No.	Max. No. of fruits	
No. 10 (W. Bengal)	Control	2/2/23	240	F.S./4/33	35	2.20
	20 m.a.H.	2/3/6	366	F.S./5/19	24	2.20
	"	2/7/13	330	F.S./7/16	55	2.30
	40 m.a.H.	2/10/7	240	F.S./17/7	35	2.30
	"	2/9/4	192	F.S./16/9	38	2.50
	60 m.a.H.	2/12/16	360	F.S./29/21	12	2.20
	"	2/12/2	102	F.S./25/11	56	2.40
	100 m.a.H.	2/13/2	264	F.S./30/3	19	—
	"	2/13/3	196	F.S./31/5	27	1.10
	200 m.a.H.	2/5/15	360	F.S./33/14	25	—
T.M.V. 1 (Madras)	"	2/6/15	270	F.S./38/3	30	—
	Control	3/30/29	135	F.S./25/33	34	2.20
	20 m.a.H.	3/33/24	205	F.S./5/14	70	2.60
	40 m.a.H.	3/35/35	223	F.S./10/17	78	2.50
	60 m.a.H.	3/37/13	210	F.S./13/10	70	2.00
	"	3/16/14	24	F.S./15/18	95	2.30
	100 m.a.H.	3/31/31	180	F.S./20/11	96	2.40
	200 m.a.H.	3/41/22	290	F.S./23/23	38	—

It will be seen from the table that during the year, in general the yield was lower both in type No. 10 and T.M.V.1. It is interesting to note that the selections in all the treatments of type No. 10 when compared between themselves, show that the low yielders of X_2 generation became higher yielders in the X_3 generation, whereas the higher yielders of X_2 generation gave low yield in the X_3 generation. The higher yielders of 20, 40 and 60 m.a.H. treatments having given 55, 38 and 56 fruits respectively, are better than the control which gave 35 fruits. The 1,000 seeds in these selections weigh 2.30, 2.50 and 2.40 gms. as against 2.20 gms. of control. This is not the case in 100 and 200 m.a.H. treatments, where the high yielders have given only 27 and 30 fruits respectively, with less seed weight, when compared with the control.

In T.M.V.1 on the contrary, the best selections of all the treatments of 20, 40, 60, 100 and 200 m.a.H., gave 70, 78, 95, 96 and 38 fruits respectively, as against 34 fruits of control. The weight of 1,000 seeds in 20, 40, 60 and 100 m.a.H. treatments were 2.60, 2.50, 2.30 and 2.40 gms. respectively, which is again higher than the seed weight of control with 2.20 gms.

C.4.1.5. *Dates of flowering and durations etc. in the selections*

Table 16 gives the flowering dates and the duration of flowering in selections of the X_7 generation and control, in Sesamum types No. 12 and 16.

TABLE 16

Type and Locality	Generation	Control and Treatment	Date of sowing	Date on which 1st plant flowered	Age at the time of flowering in days	Earliness and Lateness	Date on which last plant flowered	No. of days covered	*Date of Maximum flowering
No. 12 (West Bengal)		Control	5-4-56	7-5-56	33		30-5-56	24	16-5-56
	X_7	36 m.a.H.	"	"	33	same	"	24	15-5-56
	X_7	50 m.a.H.	"	"	33	same	2-6-56	27	19-5-56
No. 16 (West Bengal)		Control	5-4-56	12-5-56	38		4-6-56	24	16-5-56
	X_7	36 m.a.H.	"	4-5-56	30	8 days early	1-6-56	29	23-5-56
	X_7	50 m.a.H.	"	9-5-56	35	3 " "	3-6-56	26	24-5-56

(* Date on which the largest number of plants flowered)

It will be seen from the table that in type No. 12, although there is no difference in age of the plant at the time of flowering, the number of days required for complete flowering is 27 in 50 m.a.H. treatment, as against 24 days in 36 m.a.H. and control. The date on which the largest number of plants flowered (hereafter designated as maximum flowering) in 36 m.a.H. treatment was a day earlier than the control and 4 days earlier than the 50 m.a.H. treatment.

In type No. 16, flowering in 36 and 50 m.a.H. treatments was earlier than the control by 8 and 3 days respectively. The number of days required for complete flowering is 29

and 26 days in 36 and 50 m.a.H. respectively, as against 24 days in control. The maximum flowering in 36 and 50 m.a.H. treatments is 8 and 9 days later than the control.

Table 17 gives the flowering dates and the duration of flowering in selections of the X_5 generation and control, in Sesamum types No. 10 and 12.

TABLE 17

Type and Locality	Gene-ration	Control and Treatment	Date of sowing	Date on which 1st plant flowered	Age at the time of flowering in days	Earliness and Lateness	Date on which last plant flowered	No. of days covered	Date of Maximum flowering
No. 10 (West Bengal)	X_5	Control	13-4-56	22-5-56	40		29-5-56	8	29-5-56
		100 m.a.H.	"	15-5-56	33	7 days early	29-5-56	15	29-5-56
		140 m.a.H.	"	25-5-56	43	3 days late	29-5-56	5	29-5-56
No. 12 (West Bengal)	X_5	Control	13-4-56	20-5-56	38		29-5-56	10	23-5-56
		100 m.a.H.	"	19-5-56	37	1 day early	29-5-56	11	22-5-56
		140 "	"	17-5-56	35	3 days early	29-5-56	13	29-5-56

It will be seen from the table that the first flower in 100 and 140 m.a.H. treatments in type No. 10 appeared 7 days earlier and 3 days later respectively, than the control. Though the date of maximum flowering remains the same, the duration of flowering in 100 and 140 m.a.H. treatments is 15 and 5 days respectively as against 8 days of control.

In type No. 12, the selections in 100 and 140 m.a.H. treatments have been found to be flowering early by 1 day and 3 days respectively, than the control. Though the maximum flowering in 100 and 140 m.a.H. treatments is 1 day earlier and 6 days later respectively, than the control, the duration of flowering is 11 and 13 days respectively, as against 10 days of control.

Table 18 gives the flowering dates and the duration of flowering in selections of X_4 generation and control, in Sesamum type No. 10.

TABLE 18

Type and Locality	Gene-ration	Control and Treatment	Date of sowing	Date on which 1st plant flowered	Age at the time of flowering in days	Earliness and Lateness	Date on which last plant flowered	No. of days covered	Date of Maximum flowering
No. 10 (West Bengal)	X_4	Control	14-4-56	26-5-56	43		29-5-56	4	29-5-56
		140 m.a.H.	"	26-5-56	43	same	"	4	28-5-56
		200 "	"	27-5-56	44	1 day late	"	3	28-5-56
		10,000 r	"	27-5-56	44	1 day late	"	3	28-5-56
		12,500 r	"	20-5-56	37	6 days early	"	10	29-5-56

It will be seen from the table that the selection from the 12,500 r treatment was early by 6 days over control for the first flowering, while in the 200 m.a.H. and 10,000 r the selections flowered later by 1 day. The date of maximum flowering is more or less the same in treatments and control i.e. 1 day early in 140 and 200 m.a.H. and 10,000 r treatments and the same in 12,500 r treatment.

Table 19 shows the sterility and diameter of pollen grains of the selections, which are in X_7 generation during the year and control, in Sesamum types No. 12 and 16.

TABLE 19

Type and Locality	Generation	Control and Treatment	Percentage of sterile pollen grains	Pollen diameter in μ (Average of 100)
No. 12 (W. Bengal)		Control	3.24	57.19
	X_7	36 m.a.H.	3.45	57.15
	X_7	50 m.a.H.	3.50	59.71
No. 16 (W. Bengal)		Control	2.06	60.11
	X_7	36 m.a.H.	2.55	60.42
	X_7	50 m.a.H.	2.20	60.20

In general, it will be seen from the above table that both in types No. 12 and 16, the treatments 36 and 50 m.a.H. give greater pollen sterility but bigger grains, as compared to controls. There is, however, a definite relationship between maximum pollen sterility and bigger pollens. In type No. 12, the control has pollen sterility 3.24 percent and pollen diameter 57.19 μ . The respective figures in 36 m.a.H. treatment are 3.45 and 57.15 and in 50 m.a.H. treatment they are 3.50 and 59.71. In type No. 16, the control has pollen sterility 2.06 percent and a pollen diameter 60.11 μ . The respective figures in 36 m.a.H. treatment are 2.55 and 60.42 and in 50 m.a.H. treatment 2.20 and 60.20. Here 36 m.a.H. has greater sterility and bigger pollens than 50 m.a.H. and control.

G.4.1.6. Pollen sterility and size

Table 20 shows the pollen sterility and diameter of pollens of the selections, which are in X_1 generation during the year, and control in Sesamum types 12, 16, 20 and T.M.V.I and 2.

TABLE 20

Type and Locality	Generation	Control and Treatment	Percentage of sterile pollen grains	Pollen diameter in μ (Average of 100)
No. 12 (W. Bengal)		Control	5.65	60.02
	X_1	1,00,000 r	42.55	62.59
	X_1	5,00,000 r	27.28	73.58
No. 16 (W. Bengal)		Control	7.33	62.27
	X_1	1,00,000 r	29.56	62.71
No. 20 (W. Bengal)		Control	7.27	62.01
	X_1	1,00,000 r	24.07	65.01
T.M.V. 1 (Madras)		Control	11.05	63.97
	X_1	1,00,000 r	23.48	62.24
	X_1	5,00,000 r	13.92	58.42
T.M.V. 2 (Madras)		Control	13.62	61.20
	X_1	1,00,000 r	20.13	65.07
No. 16 (36 m.a.H. X_6)		Control	4.87	61.78
	X_1	2,00,000 r	55.34	63.39
No. 16 (50 m.a.H. X_6)		Control	1.98	63.52
	X_1	2,00,000 r	4.50	62.25

It will be seen from the table that in type No. 12, the control has 5.65 percent of pollen sterility, whereas the treatments of 1,00,000 and 5,00,000 r have 42.55 and 27.28 percent respectively. This is due to the very high dosage of irradiation. The increase in pollen size in two treatments, however, does not show any relationship with the sterility,^f which in the control is 60.02 μ and in treatments of 1,00,000 and 5,00,000 r, 62.59 μ and 73.58 μ respectively

In type No. 16 again, as in type No. 12, the pollen sterility and diameter in control are 7.33 percent and 62.27 μ respectively. The respective figures in 1,00,000 r treatment are 29.56 and 62.71. Here also there is not much difference in pollen diameter between treatment and control.

In type No. 20, the 1,00,000 r treatment shows 24.07 percent of sterility with pollen grains of 65.01 μ in diameter, as against the control where the respective figures are 7.27 and 62.01. Here, though the pollen diameter is more in the treatment than in the control, the pollen sterility is about 17 percent more in the treatment.

In T.M.V.1, treatments of 1,00,000 and 5,00,000 r, show 23.48 and 13.92 percent of sterility as against 11.05 percent of control. Here, the sterility is higher in the lower treatment. It is interesting to note here that the pollens in control are bigger than the treatments i.e. the pollen diameter in control is 63.97 μ as against of 62.24 μ and 58.42 μ in the treatments of 1,00,000 and 5,00,000 r

The pollen sterility in control of T.M.V. 2 is higher than any of the types considered above. It is 13.62 percent in control and 20.13 percent in 1,00,000 r treatment, a difference of only 7 percent. The pollen diameter is higher in treatment i.e. 65.07 μ as against that of control with 61.20 μ .

The table XX also shows the effects of re-irradiation, on the sterility and size of pollens of the selections. The X_6 selections of 36 and 50 m.a.H. treatments of type No. 16 when freshly irradiated with 2,00,000 r gave 55.34 and 4.50 per cent sterility, as against their controls giving 4.87 and 1.98 percent sterility respectively. It is very high in selections of 36 m.a.H., X_6 , 2,00,000 r treatment. In pollen diameter, the 36 m.a.H., X_6 , 2,00,000 r treatment exceeds slightly than control, whereas 50 m.a.H. X_6 , 2,00,000 r treatment has smaller pollens with 62.25 μ than its control with 63.52 μ .

C.4.1.7. *Behaviour of the multicoloured seed mutant*

The differently coloured seeds were separated and plants from each were grown and the necessary data, with respect to plant height, number of branches, hairiness of the plant parts, curling of leaves, size and number of locules in a capsule, colour, size and morphology of seeds, have been collected for genetical interpretation.

For the present, the percentage of oil in these various coloured seeds have been presented here.

Table 21 shows the percentage of oil in various coloured seeds of multicoloured-seed mutants, together with its parent type No. 12. For the sake of comparison, the data of

white flowered and small seeded mutants and their parent type No. 16, have also been included.

TABLE 21

Type and Locality	Control and Treatment	Percentage of Oil
No. 12 (W. Bengal)	Control	40.00
	140 m.a.H.	46.70
	<i>Multicoloured seed</i>	
	<i>Mutant isolated in X₄ generation of 140 m.a.H. treatment.</i>	
	Black	44.00
	Black and Brown	45.45
	Brown	45.45
No. 16 (W. Bengal)	Ash	53.75
	Grey	51.94
	Control	44.73
	<i>White flowered mutant isolated in X₃ generation of 50 m.a.H. treatment.</i>	43.65
	<i>Small seeded mutant isolated in X₄ generation of 36 m.a.H. treatment.</i>	51.90

It will be seen from the table that the Black seeds of the mutant has 44.0 percent oil, which is 4 percent higher than the parent control type No. 12, with 40.0 percent oil. The former has more or less the same oil content as type No. 16 and both are Black seeded. Blackish Brown and Brown seeds have the same percentage of oil i.e. 45.45, which is slightly higher than Black seeds. But Ash and Grey coloured seeds of the multi-coloured seed mutants, contain 53.75 and 51.94 percent of oil, which are about 14 and 12 percent higher respectively, than the control type No. 12. When compared to the small seeded mutant of type No. 16, which is repeatedly giving much higher percentage of oil i.e. 51.90 percent, as against its parent with 44.73 percent, the Grey coloured seeds give more or less the same percentage i.e. 51.94. The Ash coloured seeds then give about 2% more oil than its cousin, Grey coloured seeds and small seeded mutant of type No. 16 and which is also the maximum for the multi-coloured mutant.

Since these coloured seeds appear sometimes in heterogenous population, the percentage of oil in homostatic coloured seeds will clearly indicate whether this increase is due to heterozygosity or not.

BETA RAYS FROM S³⁵

C.4.1.8. Germination percentage

Table 22 shows the percentage of seed germination in Sesamum type No. 12, after treatment with beta rays from S³⁵.

TABLE 22
PERCENTAGE OF GERMINATION RECORDED ON THREE DATES

Type and Locality	Duration of treatment in hours	Date of sowing	Control* and Total Activity	Germination percentage		
				27-3-56	30-3-56	5-4-56
Type 12 (W. Bengal)	48	20-3-56	Control	28.66	32.00	12.66
			122.7 μ c	23.33	22.66	12.00
			88.7 μ c	30.66	38.66	9.33
	72	21-3-56	Control	30.66	31.33	11.33
			122.7 μ c	18.00	20.66	4.00
			88.7 μ c	12.66	14.00	10.00
	96	25-3-56	Control	19.33	26.66	15.33
			122.7 μ c	21.33	19.33	16.66
			88.7 μ c	16.66	18.00	6.66

* Soaked in distilled water.

It will be seen from the table that all the controls gave better germination percentage than their respective treatments except in 88.7 μ c for 48 hours and 122.7 μ c for 96 hours, where the germinations are slightly higher than the control. In all the treatments and controls, the maximum sprouting have been found on 30/3/56 i.e. about 5 to 10 days after sowing, after which there is a certain amount of mortality, resulting in the reduction of the number of plants, as will be seen from the records for 5/4/56. Here again, the treatment 122.7 μ c for 96 hours duration show a deviation from the rest, as there is gradual decrease in the number of surviving seedlings on the three dates.

C.4.1.9. Fruit yield, weight of seeds, height of plants etc.

Table 23 shows the number of fruits and branches, and maximum height in the best plants of the controls and treatments in Sesamum type No. 12, which are in the S₁ generation during the year.

TABLE 23

Type and Locality	Duration of Treatment in hours	Control* and initial activity	Best Plant						
			Selection No.	Max. No. of fruits	Wt. of 1000 seeds in gms.	Selection No.	Max. No. of Branches	Selection No.	Max. Height attained
Type 12 (W. Bengal)	48	Control	A/1/15	211	2.68	A/1/15	10	A/1/14	3'6"
		88.7 μ c	A/7/16	353	2.78	A/7/16	12	A/7/3	3'6"
		122.7 μ c	A/4/4	197	2.97	A/4/28	11	A/4/21	3'8"
	72	Control	B/1/32	144	2.55	B/1/32	9	B/3/29	3'0"
		88.7 μ c	B/9/23	265	3.28	B/7/50	11	B/8/39	3'10"
		122.7 μ c	B/4/25	265	2.72	B/5/27	11	B/6/29	4'0"
	96	Control	C/2/16	247	2.48	C/2/8	10	C/2/8	4'0"
		88.7 μ c	C/8/4	194	2.36	C/8/21	9	C/7/12	4'0"
		122.7 μ c	C/4/24	267	2.66	C/4/24	10	C/4/2	3'7"

* Soaked in distilled water.

It will be seen from the table that most of the selections in treatments gave higher yield of fruits than control, except in 122.7 μ c-48 hours duration, where it is 197 as against 211 of control and 88.7 μ c-96 hours duration, where it is 194 as against 247 of control. While the seeds of former, like all other treatments are heavier (i.e. 2.97 gms. per 1000 seeds) than the control (i.e. 2.68 gms per 1000 seeds), the seeds of the latter weigh less (i.e. 2.36 gms.) than the control (i.e. 2.48 gms.). Though the maximum of 353 fruits have been obtained in a selection A/7/16 of 88.7 μ c/48 hours, the heaviest seeds, viz., 3.28 gms. per thousand seeds, were obtained in a selection B/9/23 of 88.7 μ c/72 hours treatment. This has also a fairly high number of fruits i.e. 265 as against its control having 144 fruits.

In 48 and 72 hours duration, both the treatments 122.7 and 88.7 μ c s' gave increased number of branches over their respective controls. In 96 hours duration, the treatment with 122.7 μ c gave the same number of branches as that of the control, but the treatment 88.7 μ c gave one less. It is interesting to note as mentioned above, that this treatment of 88.7 μ c/96 hours also gave the least number of fruits i.e. 194 and lightest seeds i.e. 2.36 gms. per thousand seeds, as against other treatments of all the durations and controls of 48 and 96 hours. It is interesting to note that in many cases the number of fruits and branches are directly proportional. The selection B/1/32 of control/72 hours has 9 branches with 144 fruits; selections C/4/24 of 122.7 μ c/96 hours and A/1/15 of control/48 hours have 10 branches each, with 267 and 211 fruits respectively and selection A/7/16 of 88.7 μ c/48 hours has the highest number of branches i.e. 12, and fruits i.e. 353. Their behaviour with respect to these characters in subsequent generations will be studied.

In nearly all the treatments, the plants were equal or taller than their respective controls. In 122.7 μ c/96 hours however, it is shorter i.e. 3'7" as against 4'0" of control. The maximum height of 4'0" was obtained in 122.7 μ c/72 hours and control and 88.7 μ c of 96 hours.

C.4.1.10. Dates of flowering and durations in the selections

Table 24 gives the flowering dates and the duration of flowering in control and in the selections which are in the S₁ generation during the year in Sesamum type No. 12.

TABLE 24

Type and Locality	Duration of Treatment in hours	Control* and initial activity	Date of sowing	Date on which first plant flowered	Age at the time of first flowering in days	Earliness and lateness	Date on which last plant flowered	No. of days covered in flowering
Type 12 (W. Bengal)	48	Control	20-3-56	1-5-56	43	—	16-5-56	17
		88.7 μ c	"	25-4-56	37	6 days early	16-5-56	22
		122.7 μ c	"	1-5-56	43	same	16-5-56	17
	72	Control	21-3-56	28-4-56	39	—	18-5-56	21
		88.7 μ c	"	1-5-56	42	3 days late	13-5-56	13
		122.7 μ c	"	1-5-56	42	3 days late	28-5-56	28
	96	Control	25-3-56	5-5-56	42	—	15-5-56	11
		88.7 μ c	"	5-5-56	42	same	21-5-56	17
		122.7 μ c	"	5-5-56	42	same	20-5-56	16

* Soaked in distilled water.

It will be seen from the table that one of the selections in 88.7 μ c/48 hours treatment, flowered 6 days earlier than the control and the other treatment. In the 72 hours duration, treatments 122.7 and 88.7 μ c s' were later by 3 days than their controls, while in 96 hours durations, treatments and control flowered on the same day. On the whole, the treatments 122.7 and 88.7 μ c s' in 48, 72 and 96 hours durations, showed delayed duration of flowering of the population by 5 to 7 days, except the treatment 88.7 μ c/72 hours, where the flowering period is 8 days earlier than the control. Their behaviour in subsequent generations will be studied.

C.4.1.11. Pollen size and sterility

Table 25 gives the sterility and diameter of pollens in selections which are in S_1 generation during the year in Sesamum type No. 12.

TABLE 25

Type and Locality	Generation	Duration of treatment in hours	Control and Total Activity	*Percentage of sterile pollen grains	Pollen diameter in μ (Average of 100)
Type 12 (W. Bengal)	S_1	48	Control	9.15	66.48
			88.7 μ c	12.20	63.13
			122.7 μ c	12.51	66.33
	S_1	72	Control	5.61	61.05
			88.7 μ c	5.88	60.13
			122.7 μ c	7.86	64.05
	S_1	96	Control	7.43	63.22
			88.7 μ c	4.94	61.96
			122.7 μ c	7.07	61.21

* Soaked in distilled water.

It will be seen from the table that the two treatments 88.7 and 122.7 μ c s' for 48 and 72 hours durations, show progressive increase in pollen sterility than their respective controls. In 48 hours duration, while control has 9.15 percent sterile pollen grains, the 88.7 and 122.7 μ c treatments show 12.20 and 12.51 percent sterility. In 72 hours duration, control gives 5.61 percent sterile pollen grains as against 5.88 and 7.86 percent sterility in 88.7 and 122.7 μ c s' respectively. It is not so in 96 hours duration, where the control with 7.43 percent has the maximum sterility as against 4.94 and 7.07% in 88.7 and 122.7 μ c s' respectively.

As regards pollen diameter, the 72 hours duration of 122.7 μ c shows slight increase with 64.05 μ as against 61.05 in the control and 60.13 in the 88.7 μ c. In 48 and 96 hours duration, the treatments have given smaller sized pollens as compared to their respective controls. The biggest pollens have been encountered in control 48 hours. These suggest that longer soaking and the treatment in S^{35} may diminish the pollen size.

BETA RAYS FROM P^{32} C.4.1.12. *Germination percentage*

Table 26 gives the percentage of germination in P_1 generation of the year and control, in Sesamum types No. 12 and 16 and small seeded mutant of the latter.

TABLE 26

Duration of treatment in hours	Control* and initial activity	Percentage of germination		
		Type 12	Type 16	Small seeded mutant
24	Control	83.3	81.1	100.0
	300 μ c	87.7	87.7	91.2
	750 μ c	84.4	86.6	96.6
	1000 μ c	92.2	86.6	94.4
48	Control	86.6	88.8	88.8
	300 μ c	94.4	82.2	96.6
	750 μ c	87.7	91.2	91.2
	1000 μ c	91.2	93.3	95.5
72	Control	88.8	88.8	96.6
	300 μ c	90.0	96.6	98.8
	750 μ c	92.2	91.2	90.0
	1000 μ c	93.3	95.5	96.6

* Soaked in distilled water.

It will be seen from the table 26 that in the 24 hours duration, the control of the small seeded mutant had cent percent germination, while the other control types No. 16 and 12 had 81.1 and 83.3 percent, respectively. The heighest percentage of germination (i.e. 94.4) of seeds of type No. 12 has been obtained in 300 μ c—48 hours treatment and in type No. 16, in 300 μ c—72 hours treatment, where it is 96.6 percent. This indicates that the low activity with longer duration gives better germination in types No. 12 and 16. The lowest germination in small seeded mutant has been in 750 μ c—72 hours treatment, where there is 90.0 percent germination. Here, it is interesting to compare the percentage of germination between durations in all the three types. It will be seen that the activities 1,000, 750 and 300 μ c s' have given better germination than their respective controls, except 300 μ c—48 hours treatment in type No. 16 and 750 μ c—72 hours treatment in small seeded mutant.

C.4.1.13. *Pollen sterility and diameter*

Table 27 gives the sterility and diameter of pollens in the selections which are in P_1 generation during the year, in Sesamum types No. 12 and 16.

TABLE 27

Type and Locality	Duration of treatment in hours	Control* and initial activity	Percentage of sterile pollen grains	Pollen diameter in μ (Average of 100)
No. 12 (W. Bengal)		Control (Dry)	4.46	60.35
	24	Control	4.53	59.82
		300 μ c	3.89	56.44
		750 μ c	4.92	58.57
		1,000 μ c	5.14	62.48
	48	Control	5.75	56.97
		300 μ c	2.88	57.51
		750 μ c	4.00	56.80
		1,000 μ c	5.43	56.80
	72	Control	2.76	55.38
		300 μ c	4.96	57.51
		750 μ c	—	57.86
		1,000 μ c	2.89	55.38
No. 16 (W. Bengal)		Control (Dry)	5.00	56.44
	24	Control	6.94	63.19
		300 μ c	3.72	58.22
		750 μ c	4.82	56.44
		1,000 μ c	6.05	58.93
	48	Control	5.28	57.51
		300 μ c	3.30	57.50
		750 μ c	3.47	56.62
		1,000 μ c	3.55	57.86

* Soaked in distilled water.

It will be seen from the table that type No. 12 control dry seeds show 4.46 percent of sterility as against soaked controls of 24, 48 and 72 hours duration, with 4.53, 5.75 and 2.76 percent sterility respectively. This lower sterility percentages of 2.76 in control—72 hours, 2.88 in 300 μ c—48 hours, 2.89 in 1000 μ c—72 hours and 3.89 in 300 μ c—24 hours have been noted for repeat experiments and their behaviour in subsequent generations. There are, however, no significant differences in sterility between the treatments. The control dry seeds gave pollens of 60.35 μ in diameter, which again is the maximum when compared to all the other treatments and controls, except 1000 μ c—24 hours treatment, where it is 62.48 μ , i.e. higher than the control dry seeds. Apart from this there do not exist any significant differences in pollen diameter in the treatments.

In type No. 16 the control dry seeds gave 5.00 percent sterility as against 6.94 and 5.28 percent in controls of 24 hours and 48 hours respectively. All the treatments with 300, 750 and 1000 μ c in 24 and 48 hours duration show lesser sterility than their respective soaked controls. As regards the diameter of the pollen grains, the soaked control has the largest with 63.19 μ , while in the treatments and other controls, they are lower. These will be further studied in the P₂ generation.

C.4.1.14. *Cytological investigations*

Further cytological studies were conducted on the selections of *Sesamum* types T.M.V. 1, T.M.V. 2. Types 10 and 20, following X-irradiation, the dosages ranging from 1,00,000 r to 5,00,000 r. Various types of meiotic aberrations such as, clumping and stickiness, false association, extrusion, lagging of bivalents, formation of micronucleus and persistence of nucleolus through various stages of first and even second meiotic divisions, were encountered.

Cytological studies were also made on the selections of *Sesamum* types 12 and 16, which were treated with beta radiations from radioactive sulphur (S^{35}) and were in the S_1 generation, during the current year. The initial dosages given ranged from 275 μ c to 1,000 μ c and the duration from 24 hours to 96 hours. The types of aberrations noted with S^{35} were more or less similar to those noted in the X-ray treatments.

Sesamum type 12, at an initial activity of 1,000 μ c—24 hours showed 6% pollen sterility as against 18% of abnormality in the pollen mother cells and the same type at an activity 750 μ c—72 hours showed 10.2% pollen sterility, corresponding to an abnormality in pollen mother cells of 26%. It appears from the above findings that about two third of the abnormal pollen mother cells have the tendency to give rise to fertile pollens, while the rest one third expresses itself as sterile pollens.

C.4.2. *Effects of X-rays and beta rays in rape and mustard (Brassica)*

X-RAYS

C.4.2.1. *Characteristics of oil*

Table 28 gives the characteristics of oils in the X_4 -1955 progenies of Rai 5 of W. Bengal and its control.

TABLE 28

CHARACTERISTICS OF OILS

Type and Locality	Generation	Control and Treatment	Percentage of Oil	Colour by Lovibond scale	Refractive Index ND 20°C	Sap-Value	Iodine Value	Percent Non-Sap
Rai 5 (W. Bengal)		Control	30.6	Y = 41.0 R = 1.2	1.4746	174.7	106.8	0.80
	X_4	50 m.a.H.	24.7	Y = 40.0 R = 0.9	1.4749	175.6	102.9	0.86
	X_4	65 m.a.H.	28.6	Y = 40.0 R = 0.7	1.4742	175.0	102.0	0.75
	X_4	100 m.a.H.	27.2	Y = 42.0 R = 0.6	1.4746	172.5	108.2	0.70
	X_4	140 m.a.H.	34.8	Y = 41.0 R = 0.8	1.4748	172.1	104.4	0.69

It will be seen from the table that the percentage of oil in 50, 65, 100 and 140 m.a.H. treatments are 24.7, 28.6, 27.2 and 34.8 as against 30.6 percent in the control. The units

of yellow pigments in the oil remain more or less the same as in the previous years, while the red pigments show slight decrease in the treatments, as against the control. The refractive indices of oil viz :—1.4749, 1.4742, 1.4746 and 1.4748 in 50, 65, 100 and 140 m.a.H. treatments respectively, are more or less the same as in control. The saponification value of the oils of control and the treatments are more or less the same, indicating that there are no significant differences in the mean molecular weight of the mixed glycerides of these oils. As regards the iodine values, except the 100 m.a.H. treatment in which it is 108.2, no other treatments give higher values than the control which has 106.2. But the percentage of non-saponifiable matter is more in 50 m.a.H. treatment where it is 0.86, as against 0.80 in the control and it decreases with the increase of the dosages.

Table 29 gives the characteristics of oils in the X_3 —1955 progenies of Brown Sarson of E. Punjab and its control.

TABLE 29

Type and Locality	Generation	Control and Treatment	Percentage of oil	Colour by Lovibond scale	Refractive Index $N_D^{20^\circ C}$	Sap-Value	Iodine Value	Percent Non-Sap	Percentage F.F.A.
Brown Sarson (E. Punjab)		Control	45.6	Y = 30.0 R = 0.8	1.4691	163.5	93.0	0.64	1.1
	X_3	65 m.a.H.	46.3	Y = 32.0 R = 0.8	1.4698	165.2	98.0	0.70	0.5
	X_3	100 m.a.H.	47.2	Y = 34.2 R = 0.6	1.4695	163.7	96.0	0.63	0.7
	X_3	200 m.a.H.	48.4	Y = 34.0 R = 0.5	1.4697	163.1	97.5	0.73	0.6

It will be seen from the table that the presence of 46.3, 47.2 and 48.4 percent of oil in 65, 100 and 200 m.a.H. treatments respectively, shows progressive increase with the increase of the dosages, as against 45.6 percent in the control. Unlike the Sesamum types, the colour of the oil as indicated by their yellow and red pigments, does not show any change in the irradiated progenies. The refractive indices of the oils of 65, 100 and 200 m.a.H. treatments are 1.4698, 1.4695 and 1.4697 respectively, which show slight increase over that of the control with 1.4691 and hence indicate the presence of greater unsaturation. But the saponification value and the percentage of non-saponifiable matter do not show any appreciable change in the irradiated progenies, when compared to the control. The difference in iodine value of the 65, 100 and 200 m.a.H. treatments with 98.0, 96.0 and 97.5 respectively, as against 93.0 of control, is an indication of the presence of greater amount of unsaturated acids in the composition of mixed fatty acids in the oils of the irradiated progenies.

The last column, F. F. A. in the table, indicates the presence of free fatty acids in the oils having its bearing on the rancidifiability of oils, i.e. the higher the presence of free fatty acids, the greater is the tendency of the oil to rancidify. The percentage of free fatty acids is expressed as "volume of normal alcoholic caustic potash solution required to neutralise

the free fatty acids present in a sample of fat (a known weight of fat dissolved in a neutral mixture of alcohol and petrol ether, is boiled for two minutes and titrated with alcoholic caustic potash with phenolphthalene as an indicator) multiplied by 28.2 and the product divided by the weight of the sample taken". The F. F. A. percent in the oil of the control of Brown Sarson is 1.1, which is much below the inedibility unit of 3%, prescribed by the Government of India for mustard oils (vide table V, page 73 of Proceedings of the Symposium on Indian oils and Fats and their utilization held at the National Chemical Laboratory, Poona, from 7th to 9th November 1951). The F. F. A. percent in the oils of the progenies of 65, 100 and 200 m.a.H. treatments are 0.5, 0.7 and 0.6 respectively, which are not only better than the control, but also far more satisfactory on the basis of the prescribed limit and have much lower rancidifiability.

Table 30 gives the composition of essential fatty acids in the X_4 —1955 progenies of Rai 5 and in X_3 —1955 progenies of Brown Sarson and their respective controls.

TABLE 30
COMPOSITION OF ESSENTIAL FATTY ACIDS

Type and Locality	Generation	Control and Treatment	Percent Linolenic acid	Percent Linoleic acid
Rai 5 (W. Bengal)		Control	12.2	21.6
	X_4	100 m.a.H.	14.6	27.1
	X_4	140 "	14.0	24.3
Brown Sarson (E. Punjab)		Control	8.3	14.7
	X_3	65 m.a.H.	11.3	17.2
	"	100 "	10.0	14.9
	"	200 "	9.4	17.3

It will be seen from the above table that the two essential fatty acids which are present in mustard oil are lino-lenic and lino-leic acids. The essential fatty acids are mainly responsible for the digestibility and nutritional value of an edible oil. The percentages of lino-lenic and lino-leic acids in the control of Rai 5 are 12.2 and 21.6 respectively. The respective values in 100 m.a.H. treatment are 14.6 and 27.1 and in 140 m.a.H. treatment, they are 14.0 and 24.3. Similarly, the percentages of lino-lenic and lino-leic acids in the control of Brown Sarson are 8.3 and 14.7 respectively. The relative values in 65 m.a.H. treatment are, 11.3 and 17.2, in the 100 m.a.H. treatment, 10.0 and 14.9 and in 200 m.a.H. treatment 9.4 and 17.3 respectively. *Thus both in Rai 5 and Brown Sarson, the oils of the irradiated progenies contain greater amount of the essential fatty acids than the control and hence their nutritive values are better.*

Table 31 gives peroxide values of oils in X_4 —1955 progenies of Rai 5 and in X_3 —1955 progenies of Brown Sarson and their respective controls.

TABLE 31
PEROXIDE VALUE

Type and Locality	Generation	Control and Treatment	Freshly extracted Oil	Oil kept for one month
Rai 5 (W. Bengal)	X ₄	Control	14.7	29.9
		50 m.a.H.	4.9	9.1
		65 "	6.0	11.5
		100 "	5.1	11.0
		140 "	4.8	10.1
Brown Sarson (E. Punjab)	X ₃	Control	5.4	16.1
		65 m.a.H.	4.6	9.2
		100 "	3.5	6.3
		200 "	2.4	5.8

Peroxide value is a measure of deterioration of oil during storage and is dependent on the amount of antioxidant principle in the oils. It will be seen from the above table that the peroxide values in freshly extracted oil of the 50, 65, 100 and 140 m.a.H. treatments of Rai 5 are, 4.9, 6.0, 5.1 and 4.8 respectively as against 14.7 of the control and hence the former show the presence of greater amount of antioxidant principle. The peroxide value in oils when kept for a month, have been found to be 9.1, 11.5, 11.0 and 10.1 in the treatments for 50, 65, 100 and 140 m.a.H. respectively as against control with 29.9. Similarly the peroxide values of the freshly extracted oils in treatments for 65, 100 and 200 m.a.H. of Brown Sarson, are 4.6, 3.5 and 2.4 as against 5.4 of the control. This again shows the presence of greater amount of antioxidant principle in oils of these treatments. The peroxide values in the oils of treatments of 65, 100 and 200 m.a.H. when kept for a month are 9.2, 6.3 and 5.8 respectively, as against 16.1 of the control. *Thus it will be seen that lower peroxide value in one month old oils of the treatments, both in Rai 5 and Brown Sarson, show greater effectiveness of antioxidant compounds present there and the greater resistance towards rancidification than their respective controls, resulting in better keeping quality of oils.*

C.4.2.2. Yield of fruits and seeds of the early flowering selections

Table 32 gives the flowering behaviour and yield, both of fruits and seeds, of control and selected X₄ progenies of the early flowering selections of the X₃ generation of Tori 7, Rai 5 and R.L. 9.

It will be seen from the above table that in Tori 7, in 65 m.a.H., the two selections A14/1/6 and A14/1/8 flowered 2 and 4 days earlier respectively than the control. While the selection A14/1/6 gave 310 fruits and 2.02 gms. of seeds, the selection A14/1/8 gave 215 fruits and 1.45 gms. of seeds as against 260 fruits and 3.30 gms. of seeds of the control. Thus although the selection A14/1/6 alone gave more fruits than the control, in seed weight, both the selections are inferior to the control. In the whole population, although the plants of the treatments flowered earlier than the control, there is no difference in the period of flowering and the date on which the maximum number of plants flowered.

In Rai 5, selections B18/5/3 of 65 m.a.H., A19/4/3 of 100 m.a.H. and B20/5/2 of 175 m.a.H. flowered 11, 15 and 9 days earlier respectively than the control. Regarding

TABLE 32

Type and Locality	Generation	Control and Treatment	Selection No.	Date of sowing	Selection				Population			
					Date of flowering	Earliness or Lateness in days	No. of fruits	Weight of seeds in gms.	Date on which 1st plant flowered	Date on which the last plant flowered	Period of flowering in days	Date on which Maximum No. of plants flowered
Tori 7 (West Bengal)	X ₄ ,,	Control	A13/2/7	2-11-56	27-11-56	—	260	3.30	26-11-56	7-12-56	12	28-11-56
		65 m.a.H.	A14/1/6	,,	25-11-56	2 days early	310	2.02	22-11-56	3-12-56	12	29-11-56
		65 ,,	A14/1/8	,,	23-11-56	4 days early	215	1.45	22-11-56	3-12-56	12	29-11-56
Rai 5 (West Bengal)	X ₄ ,, ,,	Control	B19/3/8	2-11-56	23-12-56	—	1700	24.35	11-12-56	28-12-56	18	16-12-56
		65 m.a.H.	B18/5/3	,,	12-12-56	11 days early	1545	26.69	3-12-56	29-12-56	27	12-12-56
		100 ,,	A19/4/3	,,	8-12-56	15 ,,	1539	26.48	5-12-56	28-12-56	24	7-12-56
		175 ,,	B20/5/2	,,	14-12-56	9 days early	1872	39.85	10-12-56	26-12-56	17	14-12-56
R. L. 9 (East Punjab)	X ₄ ,, ,,	Control	D17/3/9	2-11-56	5-1-57	—	227	4.40	23-12-56	3-2-57	43	28-1-57
		200 m.a.H.	E17/5/2	,,	23-12-56	13 days early	297	5.93	18-12-56	21-1-57	35	26-12-56
		250 ,,	D19/1/13	,,	11-12-56	25 days early	1026	30.32	11-12-56	11-1-57	32	26-12-56
		250 ,,	D19/2/8	,,	1-1-57	4 days early	1758	38.77	11-12-56	11-1-57	32	26-12-56

the yield, the control gave 1700 fruits and 24.35 gms. of seeds. The relative figures in 65 m.a.H. are 1545 and 26.69, in 100 m.a.H., 1539 and 26.48 and in 175 m.a.H. 1872 and 39.85. Thus it will be seen that although the early selections in 65 and 100 m.a.H. treatments gave lower yield than the control, all the early selections in all the treatments gave higher seed weight than the control, which is remarkable in 175 m.a.H. treatment. *Hence the last early flowering selections are also higher yielders.* The plants in the 65 and 100 m.a.H. treatments have longer flowering periods than the 175 m.a.H. treatment and control, the latter two having more or less the same period. But in all the treatments, the X_4 progenies of the X_3 early flowering parents, flowered earlier than the control. Again, it is interesting to note in the treatments that the dates on which maximum number of plants flowered in the population, coincide with the dates of flowering of the individual selections which are both early flowering and higher yielders.

In R.L. 9, again, selection E17/5/2 of the 200 m.a.H. treatment and selections D19/1/13 and D19/2/8 of 250 m.a.H. treatment flowered 13, 25 and 4 days earlier than the control. Regarding the yield, the control had 227 fruits and 4.40 gms. of seeds. The relative figures in the selection E17/5/2 of 200 m.a.H., are 297 and 5.93 which although higher than the control, are much lower than the two selections of 250 m.a.H. with relative figures of 1026 and 30.32 in D19/1/13 and 1758 and 38.77 in D19/2/8. *Thus the selection D19/1/3 of 250 m.a.H. is 25 days earlier in flowering than the control and about $4\frac{1}{2}$ times higher in fruit yield and about 7 times higher in seed weight than the control.* The other selection, although gives a still higher yield of fruits and weight of seeds, is later by 21 days, but earlier than the control. *All the plants in the progenies of the treatments flowered earlier than the control covering 35 and 32 days in 200 and 250 m.a.H. treatments respectively, as against 43 days of the control. Again it is interesting to note that by the time the first plant in the control flowered (i.e. 23-12-1956), majority of the plants in the treatments had completed their flowering (i.e. date on which maximum number of plants flowered was 26-12-1956).*

However, the behaviour of the above mentioned selections in the subsequent generations will be studied.

C.4.2.3. Comparative yield of fruits and seeds in successive generations.

Table 33 gives the number of fruits produced by the best plants in the control and the selections of Rai 5 which are in X_5 generation during the current year. For purposes of comparison the number of fruits produced by these selections in the two previous generations (X_3 and X_4) are also given.

It will be seen from the table that the best selection in the treatments 50, 65, 100 and 140 m.a.H. gave 771, 920, 503 and 710 fruits respectively, which in treatments 50 and 65 m.a.H. are higher and in the treatments 100 and 140 m.a.H. are lower than the best plant of the control with 752 fruits. But the weight of seeds of these best yielders of the treatments are 8.95, 12.54, 13.22 and 13.67 gms. as against 7.52 gms. of the best control plant. The parents of these selections had given lower yield than the control in the X_4 generation. The higher yielders of the X_4 generation in all the four treatments of 50, 65, 100 and 140 m.a.H. however, gave 253, 256, 260 and 408 fruits respectively in the X_5 generation, as

TABLE 33

Type and Locality	Control and Treatment	X ₃ —54		X ₄ —55		X ₅ —56		Weight of seeds in gms.
		Selection No.	Max. No. of fruits	Selection No.	Max. No. of fruits	Selection No.	Max. No. of fruits	
Rai 5 (W. Bengal)	Control	1-D5/1/9	890	H5/8/2	285	D22/2/16	752	7.52
	50 m.a.H.	1-C1/6/2	1268	H1/5/6	548	B22/2/5	253	1.04
	50 m.a.H.	1-B1/2/15	1022	J1/3/4	200	E22/2/7	771	8.95
	65 m.a.H.	1-D2/8/6	863	J2/7/3	420	C19/2/13	256	4.35
	65 m.a.H.	1-B2/4/12	426	K2/4/3	256	E23/2/13	920	12.54
	100 m.a.H.	1-A3/1/5	1120	H3/7/2	336	A22/2/13	260	7.40
	100 m.a.H.	1-E3/3/8	341	G3/10/6	270	A19/2/6	503	13.22
	140 m.a.H.	1-A4/1/9	1030	H4/2/7	583	A20/2/7	352	7.47
	140 m.a.H.	1-C4/10/18	1108	H4/5/2	640	A23/2/11	408	4.20
	140 m.a.H.	1-D4/7/6	1100	J4/7/4	300	E19/2/15	710	13.67

against 752 fruits of the control. Seeds of these selections weighed 1.04, 4.35, 7.40 and 4.20 gms. which are less than the 7.52 gms. of seeds of the best control plant. Their behaviour in the next generation will be studied. But it is interesting to note that the seeds of the selections A19/2/6 and E19/2/15 of 100 and 140 m.a.H. treatments respectively weigh approximately double that of the seeds of the control. The yields of the fruits in the two selections are however, less than the control.

Table 34 gives the yield of selections in Tori 7, Rai 5, Brown Sarson, R.L. 9, T. 185, T. 164, T. 71 and T. 88 which are in the X₄ generation, during the year under report.

It will be seen from the above table that in the X₄ generation of Tori 7, best selections in 65, 100, 140 and 200 m.a.H. treatments gave 332, 331, 437 and 420 fruits respectively as against 444 fruits of the control. In the X₃ generation the parents of these selections had given 75, 190, 108 and 168 fruits respectively as against 210 of the control. The best selections of the X₃ generation gave much lower yield in the X₄ generation, i.e. 48, 221, 70 and 140 fruits as against 444 fruits of the control. It is interesting to note that the best selections in the X₄ generation of 65 and 140 m.a.H. treatments, with lesser number of fruits than the control, had 8.68 and 11.75 gms. of seeds respectively as against 7.02 gms. of control.

In Rai 5, in X₄ generation the best plants in 65, 100, 175 and 250 m.a.H. treatments gave 423, 403, 315 and 302 fruits respectively as against 368 fruits in the control. The X₃ parents of these selections were not the best plant of that generation. All the best selections of the year in treatments 65, 100 and 250 m.a.H. gave 5.25, 7.95 and 7.06 gms. of seeds, as against 5.22 gms. of control. In 175 m.a.H. treatment, however, another selection with 304 fruits gave 6.30 gms. of seeds as against 5.22 gms. in the control.

In Brown Sarson, in the X₄ generation, the best plants in 65, 100 and 200 m.a.H. treatments gave 210, 546 and 396 fruits respectively as against 500 fruits of the control i.e. in 100 m.a.H. treatment it is higher than the control. The X₃ parents of these selections had given 690, 280 and 250 fruits respectively as against 177 of control, which, though higher

TABLE 34

X₂—1954X₃—1955X₄—1956

Type and Locality	Control and Treatment	Selection No.	Maximum No. of fruits	Selection No.	Maximum No. of fruits	Selection No.	Maximum No. of fruits	Weight of seeds in gms.
Tori 7 (W. Bengal)	Control	3-B5/3/1	312	B5/3/17	210	E12/2/3	444	7.02
	65 m.a.H.	3-E1/6/12	395	A1/10/15	287	A7/2/12	48	0.22
	65 "	3-B1/4/6	150	C-1/4/14	75	E6/2/8	332	8.68
	100 "	3-E2/6/13	375	C2/10/7	291	E14/1/2	221	4.28
	100 "	3-D2/8/17	640	B2/7/16	190	E9/2/13	331	4.65
	140 "	3-D3/6/7	456	B3/7/13	364	B7/2/5	70	0.82
	140 "	3-B3/7/10	380	D3/3/4	108	E8/3/8	437	11.75
	200 "	3-D4/6/11	430	A4/7/12	321	A12/3/6	140	1.07
	200 "	3-C4/5/3	200	B4/6/15	168	B6/1/7	420	3.54
Rai 5 (W. Bengal)	Control	10-A5/5/18	1022	H5/1/12	308	N24/2/12	368	5.22
	65 m.a.H.	10-B1/6/5	756	I1/3/14	400	N16/2/4	235	3.40
	65 "	10-B1/6/5	756	I1/3/7	300	N25/2/9	423	5.25
	65 "	10-B1/6/5	756	H1/3/2	342	M22/2/5	340	9.32
	100 m.a.H.	10-C2/1/14	586	B2/5/10	500	K16/2/4	292	5.35
	100 "	10-B2/8/19	1224	J2/3/9	380	P22/2/5	403	7.95
	175 m.a.H.	10-F3/1/11	1900	J3/9/6	433	N22/2/8	190	2.85
	175 "	10-D3/4/10	107	G3/8/9	250	L22/2/12	315	3.27
	175 "	10-D3/6/2	959	J3/7/16	318	P23/3/3	304	6.30
	250 m.a.H.	10-D4/8/7	1300	I4/7/10	250	N20/2/13	140	2.34
	250 "	10-B4/8/14	1348	I4/3/5	442	N21/2/5	240	5.07
	250 "	10-A4/8/11	278	I4/2/2	400	P17/2/15	302	7.06
Brown Sarson (E. Punjab)	Control	1-I4/1/5	841	L1/7/6	177	G24/2/14	500	14.15
	65 m.a.H.	1-J1/1/6	993	M2/1/2	212	J24/2/13	144	6.50
	65 "	1-H1/1/6	300	N2/9/8	725	J19/2/8	162	3.81
	65 "	1-I1/3/2	408	K2/10/12	690	F18/2/4	210	5.55
	100 m.a.H.	1-F2/6/20	870	N3/5/2	267	H24/2/13	231	2.42
	100 "	1-H2/8/15	160	N3/8/3	1000	J16/2/9	207	4.77
	100 "	1-F2/3/2	105	K3/2/12	280	F21/2/17	546	9.75
	200 m.a.H.	1-G2/3/7	708	L4/4/12	540	G18/2/8	216	6.35
	200 "	1-F3/5/11	140	L4/2/9	400	G19/2/8	385	8.32
	200 "	1-H3/6/8	409	M4/7/2	540	H17/2/12	385	13.52
	200 "	1-G3/3/7	708	N4/4/2	250	J25/2/9	396	5.13
R. L. 9 (E. Punjab)	Control	F7/6/10	206	F1/7/7	156	H14/2/7	419	14.92
	65 m.a.H.	D1/9/3	181	F2/7/8	130	G6/2/15	164	6.28
	65 "	D1/9/3	181	E2/7/2	100	F7/2/13	307	7.07
	100 m.a.H.	G2/7/8	300	F3/10/10	112	H6/2/16	528	14.52
	140 "	E3/8/1	230	F4/8/2	283	G10/2/14	265	8.75
	140 "	A3/10/2	132	G4/10/8	215	K6/2/5	550	15.72
	175 m.a.H.	F4/7/8	247	G5/9/9	350	J10/2/8	256	8.15
	175 "	A4/4/6	395	F5/4/3	272	H9/2/6	519	7.33
	Control					A4/2/11	1388	33.70
	200 m.a.H.	G5/2/4	193	E6/10/12	120	A5/2/4	1694	33.45
	250 "	E6/1/11	328	F7/8/9	140	B2/2/4	283	6.30
	250 "	A6/6/3	492	E7/2/6	128	A3/2/7	1992	52.21
	250 "	A6/6/3	492	E7/2/7	80	A6/2/9	2382	43.87
T 185 (Delhi)	Control	5-C3/1/21	1452	R1/5/7	120	M7/2/14	489	11.41
	100 m.a.H.	5-C4/10/6	880	O2/5/13	216	L7/2/3	275	6.13
	100 "	5-D4/4/12	444	O2/9/4	328	L9/2/6	198	2.20
	100 "	5-B4/7/4	146	R2/4/14	215	M6/2/8	328	3.40
T 164 (Delhi)	Control	3-C2/1/22	445	M3/7/6	173	F1/2/10	1950	58.16
	100 m.a.H.	3-A2/1/24	840	L4/1/10	280	F2/3/10	1580	22.67
	100 "	3-B2/9/4	860	L4/8/3	320	F4/3/6	1300	31.84
	100 "	3-B2/6/10	302	L4/4/3	184	G3/2/8	2100	39.10
T 71 (Delhi)	Control			O1/2/3	303	E2/3/13	1096	15.70
	100 m.a.H.	A4/3/7	581	N2/2/7	400	C3/1/14	1178	21.95
T 88 (Delhi)	Control	5-D2/6/14	130	Q1/9/12	100	Q15/3/4	39	0.29
	100 m.a.H.	5-C2/7/11	490	P4/8/5	188	Q14/1/9	61	0.70

than the control, were not the maximum for that year. All the selections in the X_4 generation show lower seed weight than the control. Their behaviour in the subsequent generation will be studied. But it is interesting to note that the two selections G19/2/8 and H17/2/12 of 200 m.a.H. treatment with the same number of fruits i.e. 385 differ considerably in their seed weights, which are 8.32 and 13.52 gms. respectively.

In R.L. 9, in the X_4 generation the best plants in 65, 100, 140 and 175 m.a.H. treatments gave 307, 528, 550 and 519 fruits as against 419 fruits of the control. The progenies of best selections of the X_3 generation in 65, 140 and 175 m.a.H. treatments, however, gave 164, 265 and 256 fruits respectively as against 419 fruits of the control. The best selection K6/2/5 of 140 m.a.H. treatment gave 15.72 gms. of seeds as against 14.92 gms. of control.

The best plants in 200 and 250 m.a.H. treatments gave 1694 and 2382 fruits respectively as against 1388 fruits of their control. Seeds of these selections weigh 33.45 and 43.87 gms. respectively as against 33.70 gms. of control. In 250 m.a.H. treatment, another selection A3/2/7 with 1992 fruits gave still higher seed weight of 52.21 gms.

In T 185, in X_4 generation, the best selection in 100 m.a.H. treatment gave 328 fruits with 3.40 gms. of seeds as against 489 fruits and 11.41 gms. of seeds of control. The best selections of the previous generation, however, gave low yield in the X_4 generation.

In T 164, in X_4 generation, the best selection G3/2/8 in 100 m.a.H. treatment gave 2100 fruits as against 1950 fruits of the control. But the seeds of this selection weigh only 39.10 gms. as against 58.16 gms. of control. The progenies of the best selection L4/8/3 of the previous generation with 320 fruits gave 1300 fruits as against 1950 of control.

In T 71, in X_4 generation, the best selection C3/1/14 of 100 m.a.H. treatment gave 1178 fruits as against 1096 fruits of the control. Their respective seed weights are 21.95 and 15.70 gms.

In T 88, in X_4 generation, the best selection Q14/1/9 of 100 m.a.H. treatment gave 61 fruits and 0.7 gms. of seeds. The respective figures in the control are 39 and 0.29 gms.

Table 35 gives the yield of control and selections of Tori 7, Rai 5, Brown Sarson, R.L. 9 and T 185 which are in the X_3 generation during the year. The relative yields in the X_1 and X_2 generations have also been included for purposes of comparison.

It will be seen from the table that in Tori 7, in X_3 generation, the best selections N20/2/12 of 100 m.a.H. and N18/3/2 of 300 m.a.H. gave 248 and 405 fruits respectively as against 356 of control. These also gave higher seed weight of 9.50 and 9.11 gms. respectively as against 3.8 gms. of the control. The best progeny of best plants of X_2 generation gave in these two treatments 143 and 229 fruits respectively as against 356 of control. Their seed weights i.e. 2.21 and 2.22 gms. respectively were also lower than the control with 3.8 gms. Their behaviour in the subsequent generations will be studied.

In Rai 5, in X_3 generation, the best plants in 100 and 300 m.a.H. treatments gave 460 and 487 fruits as against 535 fruits of control. The seed weight of best plant in 100 m.a.H. treatment was 9.22 gms. which is slightly less than the seed weight of control plant.

TABLE 35

X ₁ —1954			X ₂ —1955		X ₃ —1956			Weight of seeds in gms.
Type and Locality	Control and Treatment	Selection No.	Max. No. of fruits	Selection No.	Max. No. of fruits	Selection No.	Max. No. of fruits	
Tori 7 (W. Bengal)	Control	3-F7/1/6	229	A4/2/10	213	M15/3/3	356	3.80
	100 m.a.H.	3-F8/3/3	318	A5/3/15	121	L12/2/4	143	2.21
	100 "	3-F8/3/3	318	F5/3/5	67	N20/2/12	248	9.50
	300 m.a.H.	3-B9/3/4	309	A6/2/13	105	L15/2/5	145	1.00
	300 "	3-F9/1/1	1330	A6/3/4	550	L17/3/14	229	2.22
	300 "	3-E9/5/7	800	D6/4/6	555	N18/3/2	405	9.11
Rai 5 (W. Bengal)	Control	3-G4/1/5	903	B1/2/9	283	R15/2/2	535	9.90
	100 m.a.H.	3-F5/2/5	1090	F2/2/7	500	Q19/2/17	263	2.66
	100 "	3-J5/4/1	1100	F2/1/8	625	R14/2/2	395	7.70
	100 "	3-H5/1/3	661	B2/4/14	243	Q11/2/6	460	9.22
	300 m.a.H.	3-J6/5/5	2627	F3/2/7	809	R16/2/9	388	14.35
	300 "	3-G6/5/2	788	K3/5/19	572	R11/2/11	487	8.95
Brown Sarson (E. Punjab)	Control	3-N4/4/2	524	C1/2/9	300	P10/3/17	475	15.80
	100 m.a.H.	3-C5/1/8	804	D2/1/9	173	Q8/2/12	528	13.22
	100 "	3-N5/1/3	712	D2/4/6	200	Q5/2/12	321	14.37
	100 "	3-L5/4/2	260	A2/3/3	670	Q1/2/10	778	23.75
	300 m.a.H.	3-N6/3/6	1168	C3/1/8	122	P3/2/2	416	8.00
	300 "	3-M6/3/1	480	C3/2/13	420	P6/2/10	250	6.35
R. L. 9 (E. Punjab)	Control	3-L1/3/9	703	E4/1/13	600	L7/2/18	735	8.25
	100 m.a.H.	3-L2/2/2	3594	D5/1/6	320	M10/2/6	468	11.38
	100 "	3-V2/1/4	90	B5/5/14	100	M4/2/2	612	15.75
	300 "	3-M3/1/1	3248	F6/1/9	289	N1/2/3	335	8.76
	300 "	3-Z3/3/2	2395	F6/5/8	320	N3/2/6	425	15.37
	Control	3-V1/5/9	484	2/50	411	U6/2/10	566	9.20
T. 185 (Delhi)	100 m.a.H.	3-S2/1/4	379	8/16	502	S8/2/7	428	4.96
	100 "	3-R2/2/9	255	9/23	192	U10/2/8	578	14.07
	300 m.a.H.	3-W3/1/1	170	14/5	850	T6/2/12	278	3.75
	300 "	3-W3/1/1	170	14/47	245	U9/2/11	483	15.20

In a selection R16/2/9 of 300 m.a.H. treatment with 388 fruits, the seed weight was 14.35 gms. which is higher than the control having 9.9 gms. The parent of this selection was the best plant of the X₂ generation with 809 fruits as against 283 fruits of the control. Its behaviour in the subsequent generations will be studied.

In Brown Sarson, in the X₃ generation, the best selections Q1/2/10 in 100 m.a.H. and P3/2/2 in 300 m.a.H. treatments gave 778 and 416 fruits respectively, as against 475 fruits of control. These selections gave 23.75 and 8.0 gms. of seeds respectively as against 15.8 gms. of control. While the X₂ parent of Q1/2/10 was also best yielder with 670 fruits, the X₂ parent of P3/2/2 was lower yielder with 122 fruits as against their control with 300 fruits. It is interesting to note that although a selection Q5/2/12 in 100 m.a.H. treatment gave 321 fruits, as against another selection Q8/2/12 of the treatment with 528 fruits, the seeds from the former weighed more i.e. 14.37 gms. as against 13.22 gms. in the latter.

In R.L. 9, in the X₃ generation, the best selections M4/2/2 of 100 m.a.H. and N3/2/6 of 300 m.a.H. treatments gave 612 and 425 fruits respectively as against 735 fruits of control. While the parent of the latter was also the best yielder with 320 fruits, that of the former had given only 100 fruits as against 600 fruits of control. However, all the selections in both the treatments gave higher seed weight than the control. The seed weights of best selections in 100 and 300 m.a.H. treatments are 15.75 and 15.37 gms. respectively, as against 8.25 gms. of control.

In T 185, in the X_3 generation the control gave 566 fruits and 9.2 gms. of seeds. The respective figures of the best selections in 100 m.a.H. treatment are 578 and 14.07 and in 300 m.a.H. treatment are 483 and 15.20.

Table 36 gives the yield of control and selections of R.L. 9 and T 185 which are in X_2 generation during the year. The relative figures in the X_1 generation are also given for the purposes of comparison.

TABLE 36

 X_1 —1955 X_2 —1956

Type and Locality	Control and Treatment	Selection No.	Max. No. of fruits	Selection No.	Max. No. of fruits	Weight of seeds in gms.
R. L. 9 (E. Punjab)	Control	24/25	1760	P3/2/5	654	14.67
	5,00,000 r	20/5	2200	P2/2/15	671	17.57
T. 185 (Delhi)	Control	40/6	1245	L1/2/5	1405	41.45
	5,00,000 r	41/14	580	N1/2/2	717	19.03
	16,00,000 r	43/6	1500	M1/1/15	993	32.26

It will be seen from the table that in X_2 generation of R.L. 9, the best plant in 5,00,000 r treatment gave 671 fruits as against 654 fruits of control. This selection also gave higher seed weight of 17.57 gms. as against 14.67 gms. of control.

In T 185, in X_2 generation, the best plants of 5,00,000 and 16,00,000 r treatments gave 717 and 993 fruits as against 1405 fruits of control. The seed weights of these selections are 19.03 and 32.26 gms. as against 41.45 gms. of control.

Table 37 gives the yield of the selections in Rai 5, Brown Sarson, R.L. 9, T 185, T 164 and T 71 of the X_1 generation.

TABLE 37

 X_1 —1956

Type and Locality	Control and Treatment	Selection No.	Maximum No. of fruits	Weight of seeds in gms.
Rai 5 (W. Bengal)	Control	18/38	636	8.92
	30,000 r	19/72	532	4.78
	40,000 r	20/67	570	4.45
	50,000 r	21/96	652	7.05
Brown Sarson (E. Punjab)	Control	2/87	490	9.24
	30,000 r	3/68	475	13.92
	40,000 r	4/62	412	5.91
	50,000 r	5/46	388	11.47
R. L. 9 (E. Punjab)	Control	6/51	280	3.85
	30,000 r	7/79	242	3.85
	40,000 r	8/12	232	2.74
	50,000 r	9/11	718	10.50
T 185 (Delhi)	Control	22/57	449	13.27
	30,000 r	23/64	550	15.81
	40,000 r	24/41	555	11.75
	50,000 r	25/83	998	25.69
T 164 (Delhi)	Control	10/83	872	13.10
	30,000 r	11/69	905	11.90
	40,000 r	12/34	840	11.20
	50,000 r	13/68	660	14.40
T 71 (Delhi)	Control	7/47	187	1.27
	30,000 r	5/35	111	0.45
	40,000 r	3/28	177	0.33
	50,000 r	2/4	227	2.75

It will be seen from the above table that in Rai 5, the best selections in 30,000, 40,000 and 50,000 r treatments gave 532, 570 and 652 fruits as against 636 fruits of the control. The selections, however, gave less seed yield with 4.78, 4.45 and 7.05 gms. respectively as against 8.92 gms. of control.

In Brown Sarson, in X_1 generation, the best plants in 30,000, 40,000 and 50,000 r treatments gave 475, 412 and 388 fruits respectively which are lower than the control with 490 fruits. But in seed weights the best plants of 30,000 and 50,000 r treatments, with 13.92 and 11.47 gms. respectively, are higher than the control with 9.24 gms.

In R.L. 9, in X_1 generation, the best selections in 30,000 r, 40,000 r and 50,000 r treatments gave 242, 232 and 718 fruits respectively, as against 280 fruits of control. The best plants of the first two treatments with lower fruit yields than the control, gave 3.85 and 2.74 gms respectively. But in the 50,000 r treatment, the seed weight was 10.5 gms. as against 3.85 gms. in the control.

In T 185, in X_1 generation, the best plants in 30,000, 40,000 and 50,000 r treatments gave 550, 555 and 998 fruits respectively, as against 449 fruits of control. In seed weight also, the best selections of 30,000 and 50,000 r treatments with 15.81 and 25.69 gms. are higher than the control with 13.27 gms.

In T 164, in X_1 generation, the best plants in 30,000, 40,000 and 50,000 r treatments gave 905, 840 and 660 fruits respectively, as against 872 fruits of control. It is interesting to note that though the best selection of 50,000 r treatment has given lowest yield of fruits, it gave 14.40 gms. of seeds as against 11.90 and 11.20 gms. respectively of 30,000 and 40,000 r treatments and 13.10 gms. of control.

In T 71, in X_1 generation, best plants in 30,000, 40,000 and 50,000 r treatments gave 111, 177 and 227 fruits with 0.45, 0.33 and 2.75 gms. of seeds respectively, as against 187 fruits and 1.27 gms. of seeds of control. Thus only the best selection in 50,000 r treatment gave higher yield of fruits and seeds than the control. Its behaviour in the subsequent generations will be studied.

C.4.2.4. *Dates of flowering and durations in the selections*

Table 38 gives the flowering behaviour of control and selections of Rai 5, which are in the X_5 generation during the year under report.

TABLE 38

Type and Locality	Generation	Control and Treatment	Date of sowing	Date on which 1st plant flowered	Age of the plant at 1st flowering in days	Earliness or Lateness in days	Date on which last plant flowered	No. of days covered	Date on which maximum plant flowered
Rai 5 (West Bengal)	X_5	Control	21-10-56	30-11-56	41	—	29-12-56	30	10-12-56
		50 m.a.H.	"	30-11-56	41	same	30-12-56	31	7-12-56
		65 "	21-10-56	1-12-56	42	1 day late	29-12-56	29	9-12-56
		100 "	"	19-11-56	30	11 days early	29-12-56	41	18-12-56
		140 "	"	28-11-56	39	2 days early	29-12-56	32	18-12-56

It will be seen from the above table that selections in 100 and 140 m.a.H. treatments are earlier in flowering than their control by 11 and 2 days respectively.

The date of last flowering in treatments and control being more or less the same, the number of days covered in 100 m.a.H. treatment with earliest flowering plants is maximum i.e. 41 days as against 30 days of the control, which in this treatment is expected. It is interesting to note that the date of first flowering, date of last flowering and date of maximum flowering in control and 50 and 65 m.a.H. treatments are more or less the same. However, the treatments 50 and 65 m.a.H. are earlier by 11 and 9 days respectively than the treatments 100 and 140 m.a.H. in the date of maximum flowering. Their behaviour in subsequent generations will be studied.

Table 39 gives the flowering behaviour of the selections in Tori 7, Rai 5, Brown Sarson, R.L. 9, T 185, T 164 and T 71 which are in the X_4 generation during the year under report.

TABLE 39

Type and Locality	Generation	Control and Treatment	Date of sowing	Date on which 1st plant flowered	Age at the time of flowering in days	Earliness and Lateness in days	Date on which last plant flowered	No. of days covered	Date of Maximum flowering
Tori 7 (West Bengal)	X_4	Control	21-10-56	16-11-56	27	—	27-11-56	12	24-11-56
		65 m.a.H.	"	15-11-56	26	1 day early	26-11-56	12	25-11-56
		100 "	"	14-11-56	25	2 days early	26-11-56	13	25-11-56
		140 "	"	13-11-56	24	3 " "	26-11-56	14	25-11-56
		200 m.a.H.	"	15-11-56	26	1 day early	28-11-56	14	23-11-56
Rai 5 (West Bengal)	X_4	Control	25-10-56	2-12-56	39	—	23-12-56	22	15-12-56
		65 m.a.H.	"	27-11-56	34	5 days early	23-12-56	27	6-12-56
		100 "	"	26-11-56	33	6 " "	25-12-56	30	6-12-56
		175 "	"	28-11-56	35	4 " "	22-12-56	25	6-12-56
		250 "	"	28-11-56	35	4 " "	25-12-56	28	13-12-56
Brown Sarson (East Punjab)	X_4	Control	24-10-56	29-11-56	37	—	28-12-56	30	25-12-56
		65 m.a.H.	"	30-11-56	38	1 day late	29-12-56	30	21-12-56
		100 m.a.H.	"	29-11-56	37	same	26-12-56	28	21-12-56
		200 "	"	29-11-56	37	"	28-12-56	30	15-12-56
R.L. 9 (East Punjab)	X_4	Control	24-10-56	1-12-56	39	—	21-12-56	21	11-12-56
		65 m.a.H.	"	1-12-56	39	same	31-12-56	31	9-12-56
		100 "	"	21-12-56	59	20 days late	18-1-57	29	29-12-56
		140 "	"	2-12-56	40	1 " "	9-1-57	39	9-12-56
		175 "	"	3-12-56	41	2 " "	3-1-57	32	8-12-56
	X_4	Control	9-11-56	3-1-56	56	—	22-1-57	20	8-1-57
		200 m.a.H.	"	19-12-56	41	15 days early	20-1-57	33	28-12-56
		250 "	"	25-12-56	47	9 " "	22-1-57	29	6-1-57
T.185 (Delhi)	X_4	Control	25-10-56	15-12-56	52	—	29-1-57	46	11-1-57
		100 m.a.H.	"	13-12-56	50	2 days early	9-1-57	24	30-12-56
T.164 (Delhi)	X_4	Control	23-10-56	12-12-56	51	—	4-1-57	24	21-12-56
		100 m.a.H.	"	10-12-56	49	2 days early	7-1-57	29	21-12-56
T.71 (Delhi)	X_4	Control	23-10-56	22-11-56	31	—	28-12-56	37	14-12-56
		100 m.a.H.	"	21-11-56	30	1 day early	5-1-57	46	4-1-57

It will be seen from the table that the age of the plants of Tori 7 at the time of first flowering, in treatments 65, 100, 140 and 200 m.a.H. is 26, 25, 24 and 26 days as against 27 days of the control. Thus while in treatments 65 and 200 m.a.H. plants are early in flowering by a day as against the control, in treatments 100 and 140 m.a.H. they are early by 2 and 3 days respectively. The duration of flowering in the control is of 12 days which being same in the treatment 65 m.a.H., takes 13 days in 100 m.a.H. and 14 days both in 140 and 200 m.a.H. treatments. In the treatments 65, 100 and 140 m.a.H. maximum plants flowered on 25-11-56 and in treatment 200 m.a.H. maximum plants flowered on 23-11-56 as against 24-11-56 of control. It is then one day early in 200 m.a.H. treatment and one day late in 65, 100 and 140 m.a.H. treatments as against the control.

In Rai 5, in X_4 generation selections in 65, 100, 175 and 250 m.a.H. treatments are earlier in first flowering than the control by 5, 6, 4 and 4 days respectively. The number of days covered by plants in flowering in 65, 100, 175 and 250 m.a.H. treatments are 27, 30, 25 and 28 as against 22 of control. However, it is interesting to note that in all the treatments the date of maximum flowering is much earlier than the control.

In Brown Sarson, in the X_4 generation, although the dates of first and last flowering are more or less the same in treatments and control, like Rai 5, the dates of maximum flowering, in 65 and 100 m.a.H. treatments, is earlier by 4 days, and in 200 m.a.H. treatment, it is earlier by 10 days than the control.

In R.L. 9, in the X_4 generation, treatments 200 and 250 m.a.H. flowered 15 and 9 days early respectively than their control. Treatments 100, 140 and 175 m.a.H. flowered late by 20, 1 and 2 days respectively than their control. The flowering date in 65 m.a.H. however is the same as that of control. Treatments take 8 to 18 days longer time to complete the flowering than their respective controls. But the maximum flowering in all the treatments except in 100 m.a.H. treatment takes place earlier than the control.

In T 185, in the X_4 generation, 100 m.a.H. treatment flowered 2 days early than its control. But in the duration of flowering and in the maximum flowering date the treatment is early by 22 and 12 days respectively than its control.

In T 164, in the X_4 generation, 100 m.a.H. treatment flowered 2 days earlier than its control, but it is late by 5 days in the duration of flowering.

In T 71, in the X_4 generation 100 m.a.H. treatment flowered a day earlier than its control, but it is late by 9 days in the duration of flowering.

Table 40 gives the flowering behaviour of controls and selections of Tori 7, Rai 5, Brown Sarson, R. L. 9 and T 185 which are in the X_3 generation during the year under report.

It will be seen from the table that in Tori 7, in the X_3 generation, both the control and treatments flowered the same day. In duration of flowering and the date on which maximum plants flowered 100 m.a.H. treatment is early by 6 and 2 days respectively and 300 m.a.H. treatment is late by 1 and 8 days respectively than their control.

TABLE 40

Type and Locality	Generation	Control and Treatment	Date of sowing	Date on which 1st plant flowered	Age of the plant at 1st. flowering	Early or late in days	Date on which last plant flowered	No. of days covered	Date on which maximum plants flowered
Tori 7 (West Bengal)	X ₃	Control	22-11-56	16-12-56	25	—	6-1-57	22	26-12-56
		100 m.a.H.	"	16-12-56	25	same	31-12-56	16	24-12-56
		300 "	"	16-12-56	25	same	7-1-57	23	3-1-57
Rai 5 (West Bengal)	X ₃	Control	22-11-56	2-1-57	42	—	29-1-57	28	19-1-57
		100 m.a.H.	"	28-12-56	37	5 days early	19-1-57	23	8-1-57
		300 "	"	30-12-56	39	3 days early	1-2-57	33	8-1-57
Brown Sarson (East Punjab)	X ₃	Control	22-11-56	30-12-56	39	—	20-1-57	22	3-1-57
		100 m.a.H.	"	28-12-56	37	2 days early	20-1-57	24	17-1-57
		300 "	"	16-12-56	25	14 days early	31-1-57	47	17-1-57
R. L. 9 (East Punjab)	X ₃	Control	22-11-56	14-1-57	54	—	7-2-57	25	1-2-57
		100 m.a.H.	"	17-1-57	57	3 days late	7-2-57	22	26-1-57
		300 m.a.H.	"	17-1-57	57	3 " "	7-2-57	22	6-2-57
T. 185 (Delhi)	X ₃	Control	4-11-56	28-12-56	45	—	18-2-57	53	24-1-57
		100 m.a.H.	"	27-12-56	44	1 day early	16-2-57	52	9-2-57
		300 m.a.H.	"	30-12-56	47	2 days late	17-2-57	50	8-2-57

In Rai 5, in the X₃ generation, both the treatments 100 and 300 m.a.H. flowered 5 and 3 days early respectively than their control. In both the treatments maximum plant flowered 11 days early than their control. In duration of flowering while 100 m.a.H. treatment is early by 5 days, 300 m.a.H. treatment is late by 5 days.

In Brown Sarson, in the X₃ generation, treatments 100 and 300 m.a.H. flowered 2 and 14 days early than their control. These treatments take longer time for completion of flowering and the maximum flowering date is 14 days later than the control.

In R.L. 9, in the X₃ generation, both the treatments 100 and 300 m.a.H. are late by 3 days in flowering, but are early by 3 days in the duration of flowering. However the maximum number of plants in 100 m.a.H. treatment flowered 6 days earlier than the control.

In T 185, in the X₃ generation, the treatment 100 m.a.H. flowered 1 day earlier than the control. The date on which the maximum plants flowered is much later in the two treatments than the control.

Table 41 gives the flowering behaviour of controls and selections of Brown Sarson, R.L. 9 and T 185, which are in the X₂ generation during the year under report.

It will be seen from the above table that in Brown Sarson, the only treatment 14,00,000 r flowered 2 days early than its control. It completed flowering 4 days earlier than the control and is earlier in date of maximum flowering.

In R.L. 9, in the X₂ generation, the only treatment 5,00,000 r flowered 9 days early than its control. The date on which maximum plants flowered is also 2 days early than its control.

TABLE 41

Type and Locality	Gene-ration	Control and Treatment	Date of sowing	Date on which 1st. plant flowered	Age of the plant at 1st flowering in days	Early or late in days	Date on which last plant flowered	No. of days covered	Date on which maximum plants flowered
Brown Sarson (East Punjab)	X ₂	Control	26-10-56	2-12-56	38	—	5-1-57	35	16-12-56
		14,00,000 r	„	30-11-56	36	2 days early	30-12-56	31	15-12-56
R. L. 9 (East Punjab)	X ₂	Control	26-10-56	10-1-57	46	—	31-1-57	22	16-1-57
		5,00,000 r	„	1-1-57	37	9 days early	31-1-57	31	14-1-57
T 185 (Delhi)	X ₂	Control	26-10-56	10-12-56	46	—	19-1-57	41	27-12-56
		5,00,000 r	„	20-12-56	56	10 days late	16-1-57	28	31-12-56
		16,00,000 r	„	10-12-56	46	same	20-1-57	42	21-12-56

In T 185, in the X₂ generation, the treatment 5,00,000 r flowered 10 days later than its control. The treatment 16,00,000 r flowered together with the control, but the maximum number of plants in the latter flowered 6 days earlier than its control.

Mean yield of seeds in gms.

For the purpose, best selections of the previous generations were sown in plots of completely randomised design lay-out and after the bulk harvest of the individual plot, mean yield of seeds per plant in the progenies has been calculated.

Table 42 shows the mean yield of seeds per plant in control and treatments of R.L. 9, which are in the X₄ generation during the year under report.

TABLE 42

Type and Locality	Control and Treatment	Mean yield of seeds per plant in gms.
R. L. 9 (E. Punjab)	Control	2.79
	65 m.a.H.	2.79
	100 „	4.66
	140 „	3.43
	175 „	2.95

It will be seen from the table that in the X₄ generation in R.L. 9, the mean yield of seeds per plant in the treatments 65, 100, 140 and 175 m.a.H. are 2.79, 4.66, 3.43 and 2.95 gms. as against 2.79 gms. in control i.e. *all the treatments except 65 m.a.H. gave higher mean yield.*

Table 43 shows the mean yield of seeds per plant in control and treatments of Rai 5, Brown Sarson and R.L. 9 which are in the X₃ generation during the year under report.

TABLE 43

Type and Locality	Control and Treatment	Mean yield of seeds per plant in gms.
Rai 5 (W. Bengal)	Control	2.17
	100 m.a.H.	2.90
	300 ,,	3.87
Brown Sarson (E. Punjab)	Control	4.64
	100 m.a.H.	4.60
	300 ,,	5.29
R. L. 9 (E. Punjab)	Control	3.33
	100 m.a.H.	3.68
	300 ,,	3.07

It will be seen from the table that in Rai 5, in the X_3 generation, treatments 100 and 300 m.a.H. gave mean seed weight of 2.90 and 3.87 gms. respectively as against 2.17 gms. in control *i.e.* both the treatments gave higher mean yield than their control.

In Brown Sarson in the X_3 generation treatments 100 and 300 ma.H. gave mean seed weight of 4.60 and 5.29 gms. respectively as against 4.64 gms. of control *i.e.* only 300 m.a.H. treatment gave higher mean yield than its control.

In R.L. 9 in the X_3 generation both the treatments 100 and 300 ma.H. gave mean seed weight of 3.68 and 3.07 gms. respectively as against 3.33 gms. in control *i.e.* only 100 m.a.H. treatment gave higher seed yield than its control.

BETA RAYS FROM S^{35}

C.4.2.5. Germination percentage

Table 44 gives the percentage of germination in the treatments with S^{35} and the controls in Rai 5 and B. Sarson, which are in S_1 generation.

It will be seen from the table that Rai 5 dry control seeds show initial germination of 42.0 percent which at the end of 20 days period falls to 41 percent. Control 24 hrs. duration shows initial germination percentage of 41.0 which due to delayed germination shows, at the end of 20 days period, 43.0 per cent. In 48 hrs. duration, the activities 452.64, 678.96 and 905.28 μ cs show germination percentage of 54.0, 50.0 and 49.0 respectively, which are higher than the control and show a progressive decrease with the increased activities. In 72 hrs. duration the control shows 57.0 per cent germination, as against the germination percentage of 47.0, 58.0 and 40.0 in activities 452.64, 678.96 and 905.28 μ cs, respectively. This increase of 58.0 percent in the 678.96 μ c activity with initial germination percentage of 54.0, is due to delayed germination. In 96 hrs. duration, the control with initial germination percentage of 46.0 has on 11/1/1957, 40.0 per cent, which, in the three activities 452.64, 678.96 and 905.28 μ cs, show 50.0, 54.0 and 41.0 percent respectively.

TABLE 44

Type and Locality	Dry and duration	Control* and total Activity	Percentage of germination in S ₁ generation			
			5th day after sowing	30-12-56	5-1-57	11-1-57
Rai 5 (W. Bengal)	Dry	Control	42.0	42.0	41.0	41.0
	24	Control	41.0	43.0	43.0	43.0
	"	452.64 μ c	36.0	40.0	42.0	42.0
	"	678.96 μ c	43.0	47.0	48.0	50.0
	"	905.28 μ c	43.0	40.0	40.0	40.0
	48	Control	36.0	41.0	43.0	46.0
	"	452.64 μ c	61.0	58.0	55.0	54.0
	"	678.96 μ c	47.0	49.0	50.0	50.0
	"	905.28 μ c	47.0	49.0	49.0	49.0
	72	Control	51.0	55.0	56.0	57.0
	"	452.64 μ c	50.0	49.0	48.0	47.0
	"	678.96 μ c	54.0	58.0	58.0	58.0
	"	905.28 μ c	41.0	40.0	40.0	40.0
	96	Control	46.0	43.0	41.0	40.0
	"	452.64 μ c	61.0	53.0	50.0	50.0
	"	678.96 μ c	48.0	53.0	54.0	54.0
	"	905.28 μ c	56.0	45.0	41.0	41.0
Brown Sarson (E. Punjab)	Dry	Control	40.0	31.0	26.0	25.0
	24	Control	36.0	25.0	23.0	23.0
	"	452.64 μ c	39.0	28.0	25.0	23.0
	"	678.96 μ c	53.0	40.0	33.0	31.0
	"	905.28 μ c	38.0	33.0	25.0	23.0
	48	Control	28.0	25.0	15.0	13.0
	"	452.64 μ c	29.0	22.0	18.0	16.0
	"	678.96 μ c	41.0	20.0	14.0	14.0
	"	905.28 μ c	27.0	18.0	13.0	13.0
	72	Control	20.0	14.0	11.0	11.0
	"	452.64 μ c	19.0	13.0	13.0	13.0
	"	678.96 μ c	33.0	19.0	17.0	17.0
	"	905.28 μ c	14.0	18.0	17.0	17.0
	96	Control	16.0	15.0	13.0	13.0
	"	452.64 μ c	11.0	15.0	18.0	18.0
	"	678.96 μ c	20.0	36.0	38.0	38.0
	"	905.28 μ c	9.0	25.0	20.0	20.0

*Soaked in distilled water.

In Brown Sarson, the control dry seeds show initial germination of 40.0 percent, which falls to 25.0 per cent at the end of the period. In 24 hrs. duration, while the control and 452.64 and 905.28 μ cs show more or less the same trend in germination with 23.0 percent at the end of 20 days period, the activity 678.96 μ c show 31.0 percent germination, which had initial germination percentage of 53.0. In 48 hrs. duration, the control show 13.0 percent germination whereas the three activities 452.64, 678.96 and 905.28 μ cs show 16.0, 14.0 and 13.0 germination at the end of the period, i.e. decrease in germination percentage, with increased activities. The activities 452.64, 678.96 and 905.28 μ c in 72 hrs. duration show 13.0, 17.0 and 17.0 per cent respectively, as against 11.0 per cent of control i.e. a pro-

gressive increase with the increased activities. Similarly, in 96 hrs. duration there is also an increase in the germination percentage in these activities, where 678.96 μ c show the maximum of 38.0 percent.

C.4.2.6. Fruit and seed yield in the selections

Table 45 gives the yield of control and selections of Rai 5 and Brown Sarson which are in S_1 generation during the year under report.

TABLE 45
 S_1 —1956

Type and Locality	Dry and Duration in hours	Control* and initial Activity	Selection No.	Best Plant	
				No. of fruits	Seed weight in gms.
Rai 5 (W. Bengal)	Dry	Control	1/71	627	13.98
	24	Control	2/61	784	9.06
	"	452.64 μ c	3/66	820	16.02
	"	678.96 μ c	4/31	639	10.28
	"	905.28 μ c	5/69	490	7.89
	48	Control	6/55	403	5.35
	"	452.64 μ c	7/11	333	5.95
	"	678.96 μ c	8/34	569	4.92
	"	905.28 μ c	9/57	398	8.70
	72	Control	10/38	519	6.81
	"	452.64 μ c	11/59	694	10.62
	"	678.96 μ c	12/49	539	12.02
	"	905.28 μ c	13/75	470	5.57
	96	Control	14/10	407	8.89
	"	452.64 μ c	15/43	270	2.52
	"	678.96 μ c	16/22	363	6.50
	"	905.28 μ c	17/42	425	8.75
Brown Sarson (E. Punjab)	Dry	Control	18/4	320	4.95
	24	Control	19/15	399	7.30
	"	452.64 μ c	20/29	212	3.25
	"	678.96 μ c	21/50	386	2.38
	"	905.28 μ c	22/2	560	4.57
	48	Control	23/29	115	1.59
	"	452.64 μ c	24/95	467	4.83
	"	678.96 μ c	25/32	496	2.82
	"	905.28 μ c	26/81	438	8.48
	72	Control	27/20	353	6.20
	"	452.64 μ c	28/28	540	12.20
	"	678.96 μ c	29/49	338	3.86
	"	905.28 μ c	30/48	298	4.61
	96	Control	31/43	624	8.00
	"	452.64 μ c	32/42	300	4.22
	"	678.96 μ c	33/4	305	5.25
	"	905.28 μ c	35/43	945	9.00

* Soaked in distilled water.

It will be seen from the above table that in Rai 5, control dry seeds gave a maximum of 627 fruits with 13.98 gms. of seeds. In 24 hrs. duration the best plants in 452.64, 678.96 and 905.28 μ c treatments gave 820, 639 and 490 fruits respectively, as against 784 fruits of control. The selection of 452.64 and 678.96 μ c treatments gave 16.02 and 10.28 gms. of

seeds respectively, as against 9.06 gms. of control. In the 48 hours duration, the best selections in 452.64 and 905.28 μ c treatments, though gave lesser number of fruits i.e. 333 and 398 respectively as against 403 of control, gave greater yield of seeds i.e. 5.95 and 8.70 gms. respectively as against 5.35 gms. of control. On the contrary while the best selection in 678.96 μ c treatment gave more number of fruits i.e. 569 as against 403 fruits of control, it gave lesser seed weight of 4.92 gms. as against 5.35 gms. of control. In 72 hours duration, the best selections in 452.64 and 678.96 μ c treatments gave higher number of fruits i.e. 694 and 539 respectively as against 519 of control and also gave higher seed weight i.e. 10.62 and 12.02 gms. respectively as against 6.81 gms. of control. In the third treatment with 905.28 μ c, the best plant gave lower number of fruits i.e. 470 and lower seed weight i.e. 5.57 gms. as against the control. In the 96 hours duration, unlike 72 hours duration, the best selections in treatments 452.64 and 678.96 μ c, gave lesser fruit yield i.e. 270 and 363 respectively as against 407 of control and lesser seed weight i.e. 2.52 and 6.50 gms. respectively as against 8.89 gms. of control. In 905.28 μ c treatment the best selection gave higher number of fruits and seed weight than the other treatments and control.

In Brown Sarson, in S_1 generation, the best plant 18/4 in control dry seeds gave 320 fruits with 4.95 gms. of seeds. In 24 hours duration, the best plants in 452.64, 678.96 and 905.28 μ cs' gave 212, 386 and 560 fruits, as against 399 fruits of control. Seeds of all the treatments 452.64, 678.96 and 905.28 μ cs' with 3.25, 2.38 and 4.57 gms. respectively, are less than the 7.30 gms. of seeds of control. The control 24 hours, however, gave more yield of seeds than the dry control. In 48 hours duration, the best selections in 452.64, 678.96 and 905.28 μ cs' gave 467, 496 and 438 fruits and 4.83, 2.82 and 8.48 gms. of seeds respectively, as against 115 fruits and 1.59 gms. of seeds of control. Thus in all the three treatments the yield of fruits and seeds is higher than the control. It is interesting to note that the 905.28 μ c treatment, although gave only 438 fruits which is the lowest amongst the treatments, had the highest seed weight of 8.48 gms. In 72 hours duration, the best plant in 452.64, 678.96 and 905.28 μ cs' gave 540, 338 and 298 fruits respectively as against 353 fruits of control. These selections of the three treatments gave 12.20, 3.86 and 4.61 gms. of seeds respectively as against 6.20 gms. of control. Here, the selection in 452.64 μ c treatment gave both maximum yield of fruits and seeds. In 96 hours duration, the best plants in 452.64, 678.96 and 905.28 μ cs' gave 300, 305 and 945 fruits as against 624 fruits of control. These selections of the three treatments gave 4.22, 5.25 and 9.00 gms. of seeds as against 8.00 gms. of seeds of control. Here the best selection of 905.28 μ c treatment gave maximum yield of fruits and seeds. Thus the maximum yielders 22/2 of 905.28 μ c/24 hrs. and 25/32 of 678.96 μ c/48 hrs. are lower in yield of seeds than the control dry seeds. On the contrary the maximum yielders 28/28 of 452.64 μ c/72 hrs. and 35/43 of 905.28 μ c/96 hrs. give higher yield of seeds than not only with the control dry seeds, but also with all the other treatments and control. Their behaviour in the subsequent generations will be studied.

C.4.2.7. *Dates of flowering and durations in the selections*

Table 46 gives the flowering dates in the selections and controls in the S_1 generation (Beta rays from S^{35}), in Rai 5 and Brown Sarson.

It will be seen from the above table that in Rai 5 control dryseeds, the first plant flowered on the 51st day and the last plant flowered on the 61st day, giving flowering duration of 11 days only. The treatments 452.64 and 678.96 μ c in 24 hours duration and 452.64 μ c in 48 hours duration gave plants which were 1, 2 and 1 day early respectively than their control in first flowering. However, all the treatments and their respective controls took 1 to 7 days longer time for completion of flowering than the control dryseeds.

In control dryseeds of Brown Sarson, the first plant flowered on the 49th day and the last plant flowered on the 61st day, giving flowering duration of 13 days. In 24

TABLE 46

Type and Locality	Dry and Duration in hours	Control* and Treatment	Date of sowing	Date of 1st flowering	Age at the time of 1st flowering in days	Earliness and Lateness in days	Date on which last plant flowered	Age at the time of last flowering in days	Duration of flowering in days
Rai 5 (W. Bengal)	24	Control	15-12-56	3-2-57	51	—	13-2-57	61	11
		Control	"	31-1-57	48	—	16-2-57	64	17
		452.64 μ c	"	30-1-57	47	1 day early	15-2-57	63	17
		678.96 μ c	"	29-1-57	46	2 days early	13-2-57	61	16
		905.28 μ c	"	1-2-57	49	1 day late	13-2-57	61	13
	48	Control	16-12-56	1-2-57	48	—	16-2-57	63	16
		452.64 μ c	"	31-1-57	47	1 day early	11-2-57	58	12
		678.96 μ c	"	1-2-57	48	same	16-2-57	63	16
		905.28 μ c	"	1-2-57	48	same	14-2-57	61	14
	72	Control	17-12-56	28-1-57	43	—	14-2-57	60	18
		452.64 μ c	"	1-2-57	47	4 days late	11-2-57	57	11
		678.96 μ c	"	1-2-57	47	4 " "	15-2-57	61	15
		905.78 μ c	"	3-2-57	49	6 days late	41-2-57	60	12
	96	Control	18-12-56	29-1-57	43	—	13-2-57	58	16
		452.64 μ c	"	1-2-57	46	3 days late	17-2-57	62	17
		678.96 μ c	"	3-2-57	48	5 days late	18-2-57	63	16
		905.28 μ c	"	4-2-57	49	6 days late	14-2-57	59	11
	Brown Sarson (E. Punjab)	Control	15-12-56	1-2-57	49	—	13-2-57	61	13
		Control	"	3-2-57	51	—	13-2-57	61	11
		452.64 μ c	"	3-2-57	51	same	17-2-57	65	15
		678.96 μ c	"	2-2-57	50	1 day early	18-2-57	66	17
		905.28 μ c	"	2-2-57	50	1 day early	14-2-57	62	13
		Control	16-12-56	4-2-57	51	—	17-2-57	64	14
		452.64 μ c	"	2-2-57	49	2 days early	18-2-57	65	17
		678.96 μ c	"	3-2-57	50	1 day early	16-2-57	63	14
		905.28 μ c	"	5-2-57	52	1 day late	11-2-57	58	7
		Control	17-12-56	2-2-57	48	—	12-2-57	58	11
		452.64 μ c	"	3-2-57	49	1 day late	11-2-57	57	9
		678.96 μ c	"	5-2-57	51	3 days late	16-2-57	62	12
		905.28 μ c	"	5-2-57	51	3 " "	16-2-57	62	12
	96	Control	18-12-56	5-2-57	50	—	14-2-57	59	10
		452.64 μ c	"	5-2-57	50	same	16-2-57	61	12
		678.96 μ c	"	5-2-57	50	same	13-2-57	58	9
		905.28 μ c	"	27-1-57	41	9 days early	16-2-57	61	21

*Soaked in distilled water.

hours duration, both in 678.96 and 905.28 μ c treatments, first plant flowered 1 day earlier than their control. In 48 hours duration, in 452.64 and 678.96 μ c treatments first plant flowered 2 days and 1 day earlier respectively than their control. In 96 hours duration, only 905.78 μ c treatment gave plants which flowered as early as 9 days than its control. The low flowering duration of 7, 9, 10 and 9 days in 905.28 μ c/48 hours, 452.64 μ c/72 hours, control/96 hours and 678.96 μ c/96 hours treatments respectively is due to their late flowering of the first plant.

C.4.2.8. pollen diameter and sterility

Table 47 gives the size of pollen grains in the control and treatments of Rai 5 and Brown Sarson which are in S_1 generation during the year under report.

TABLE 47

Type and Locality	Generation	Duration in hours	Control* and initial Activity	Pollen diameter in μ (Average of 100)
Rai 5 (W. Bengal)	S_1	Dry	Control	25.43
		24	Control	25.82
		"	452.64 μ c	28.78
		"	678.96 μ c	29.17
		"	905.28 μ c	29.17
	S_1	48	Control	26.43
		"	452.64 μ c	33.77
		"	678.96 μ c	27.46
	S_1	72	Control	25.99
		"	452.64 μ c	27.10
		"	678.96 μ c	28.78
		"	905.28 μ c	28.66
	S_1	96	Control	26.02
		"	452.64 μ c	27.30
		"	678.96 μ c	28.63
		"	905.28 μ c	28.08
Brown Sarson (E. Punjab)	S_1	24	Control	23.00
		"	452.64 μ c	24.57
		"	678.96 μ c	24.41
		"	905.28 μ c	24.58
	S_1	48	Control	23.01
		"	452.64 μ c	24.34
		"	678.96 μ c	24.42
		"	905.28 μ c	24.18
	S_1	72	Control	24.02
		"	452.64 μ c	23.87
		"	678.96 μ c	23.44
		"	905.28 μ c	25.12
	S_1	96	Control	24.49
		"	452.64 μ c	26.36
		"	678.96 μ c	24.18
		"	905.28 μ c	23.98

*Soaked in distilled water.

It will be seen from the table that in Rai 5 in the control dryseeds, the pollen diameter is 25.43μ . In all the controls and treatments of durations 24, 48, 72 and 96 hours, slight increase in the pollen diameter has been recorded. Again, the increase in the pollen diameter in the radio-sulphur treatments is more than their respective controls and remarkably so in $452.64\mu\text{c}/48$ hours treatment where it is 33.77μ as against 26.43μ of its control.

In Brown Sarson, in S_1 generation all the treatments in 24 and 48 hours durations, show increase in pollen diameter over their respective controls. In 72 hours duration, 452.64 and $678.96\mu\text{c}$ treatments have pollen diameter 23.87 and 23.44 as against 24.02μ of their control. Similarly in $905.28\mu\text{c}/96$ hours the pollen diameter of 23.98μ is less than 24.49μ of its control. In rest of the treatments of 72 and 96 hours durations the pollen diameter is more than their respective controls.

Table 48 gives the percentage of sterile pollen grains in controls and radio sulphur (S^{35}) treatments of Rai 5 and Brown Sarson, which are in S_1 generation during the year under report.

TABLE 48

Type and Locality	Generation	Duration in hours	Control* and initial Activity	Percentage of sterile pollen grains
Rai 5 (W. Bengal)	S_1	Dry	Control	2.29
		24	Control	3.40
		"	$452.64\mu\text{c}$	3.92
	S_1	48	Control	5.40
		"	$905.28\mu\text{c}$	5.93
		"	"	"
Brown Sarson (E. Punjab)	S_1	Dry	Control	2.55
		24	Control	2.92
		"	$905.28\mu\text{c}$	5.45
	S_1	72	Control	2.80
		"	$452.64\mu\text{c}$	5.95
		"	$678.96\mu\text{c}$	4.80
	"	"	$905.28\mu\text{c}$	5.49

*Soaked in distilled water.

It will be seen from the table that Rai 5 control dryseeds show 2.29 percent sterility. In 24 hours duration the treatment $452.64\mu\text{c}$ gave 3.92 percent sterile pollen grains against 3.40 percent of control. Similarly, in 48 hours duration treatment $905.28\mu\text{c}$ gave 5.93 percent sterile pollen grains against 5.40 of control.

In Brown Sarson, like Rai 5, both in 24 and 72 hours duration, all the treatments gave 2 to 3 per cent more sterile pollen grains against their respective controls.

BETA RAYS FROM P^{32}

C.4.2.9. Germination percentage

Table 49 gives the percentage of germination of seeds in treatments (P_1 generation) and controls in Rai 5 and Brown Sarson,

TABLE 49

Type and Locality	Duration in hours	Control* and Total Activity	Percentage of germination on			
			15-12-56	20-12-56	25-12-56	30-12-56
Rai 5 (W. Bengal)	Dry	Control	66.5	74.5	77.0	77.0
	24	Control	68.5	71.5	74.0	75.5
	"	880.50 μ c	62.5	62.5	63.0	63.0
	"	1320.75 μ c	65.5	64.5	64.5	64.5
	"	1761.00 μ c	70.0	71.0	73.0	74.5
	48	Control	67.0	69.0	69.0	69.0
	"	880.50 μ c	85.5	86.5	87.5	87.5
	"	1320.75 μ c	81.0	74.0	73.5	73.5
	"	1761.00 μ c	62.0	61.5	61.0	61.0
	72	Control	63.0	62.5	60.5	60.5
	"	880.50 μ c	64.0	57.5	55.5	55.5
	"	1320.75 μ c	76.0	60.0	54.5	52.2
	"	1761.00 μ c	57.0	48.0	43.0	42.0
Brown Sarson (E. Punjab)	Dry	Control	77.0	57.5	44.0	41.5
	24	Control	50.5	42.0	33.5	30.0
	"	880.50 μ c	55.5	50.0	43.5	41.0
	"	1320.75 μ c	63.5	51.5	47.0	44.5
	"	1761.00 μ c	60.0	52.5	47.0	46.0
	48	Control	64.5	55.0	42.0	37.5
	"	880.50 μ c	66.0	41.0	39.5	39.5
	"	1320.75 μ c	45.5	37.5	31.5	30.5
	"	1761.00 μ c	54.5	41.5	37.5	37.0
	72	Control	47.5	40.0	31.5	31.0
	"	880.50 μ c	35.0	29.0	24.0	23.0
	"	1320.75 μ c	41.5	30.0	26.0	26.0
	"	1761.00 μ c	23.0	25.0	19.5	18.0

* Soaked in distilled water.

It will be seen from the table that Rai 5, dry seeds show initial germination of 66.5 percent, which after 15 days was 77.0 percent, i.e. an increase of 10.5 percent during the germination period. In 24 hours duration, the control seeds again show the maximum percentage of 75.5 at the end of germination period of 15 days, the initial percentage being 68.5, which was lower than the initial percentage of 70.0 in 1761.00 μ c, which, at the end of the period, gave 74.5 percent germination. Like the control dry seeds, control/24 hours, 880.5 μ c/24 hours and 1761.0 μ c/24 hours treatments show progressive increase in germination during the period, as against the 1320.75 μ c treatment where there was decrease in percentage of germination. In 48 hours duration, only control and 880.5 μ c activity show progressive increase in percentage of germination during the period, which in case of 880.5 μ c with 87.5 percent germination is highest. The two activities 1320.75 and 1761.00 μ c, on the other hand, show progressive decrease during the period, with the result that in these durations, with the increase in the activity there is fall in the percentage of germination. In the 72 hrs. duration, control and all the three activities of 880.5, 1320.75 and 1761.00 μ c, show decrease in the percentage of germination during the period. Here again like the 48 hours duration, there is fall in the percentage of germination with the increase in the activity.

Brown Sarson dry seeds show initial germination percentage of 77.0, which, at the end of 15 days period, falls to 41.5 percent, due to the mortality of seedlings. In 24 hrs. duration, control shows initial germination of 50.5 percent, which, at the end of the germination period, falls to 30.00 percent. This is the least in 24 hrs. duration, when compared to other three activities of 880.5, 1320.75 and 1761.00 μ c, which, like the 24 hrs. duration of Rai 5, show progressive increase of 41.0, 44.5 and 46.0 percent germination with the increase in the activities. In 48 and 72 hours duration in Brown Sarson, in general, there is decrease in the germination percentage in various activities and durations, when compared to the controls.

TABLE 50

Type and Locality	Dry and duration of soaking in hours	Control* and initial Activity	Selections No.	Best Plant	
				No. of fruits	Weight of seeds in gms.
Rai 5 (W. Bengal)	Dry	Control	1/6	526	12.50
		Control	3/67	820	13.48
		126.69 μ c	55/60	240	3.41
		379.38 μ c	56/19	326	3.56
		514.01 μ c	57/14	418	4.50
		880.5 μ c	5/10	600	11.05
	24	1320.75 μ c	8/41	407	10.34
		1761.00 μ c	10/29	270	2.75
		Control	11/49	338	2.37
		126.69 μ c	59/48	398	5.95
		379.38 μ c	60/28	206	2.47
		514.01 μ c	61/3	228	1.92
	48	880.50 μ c	14/1	180	4.52
		1320.75 μ c	16/22	363	2.03
		1761.00 μ c	17/20	375	4.85
		Control	20/21	670	7.40
		126.69 μ c	63/23	283	2.05
		379.38 μ c	64/54	292	4.05
	72	514.01 μ c	65/10	271	3.28
		880.50 μ c	21/22	675	5.91
		1320.75 μ c	23/38	258	5.32
		1761.00 μ c	25/64	531	3.81
Brown Sarson (E. Punjab)	Dry	Control	27/5	207	0.60
		Control	30/32	366	5.35
		123.69 μ c	68/21	289	5.00
		393.64 μ c	69/37	102	2.75
		456.90 μ c	70/18	283	6.30
		880.50 μ c	32/18	409	4.00
	24	1320.75 μ c	34/32	467	3.65
		1761.00 μ c	35/22	364	4.20
		Control	37/21	319	4.87
		123.69 μ c	72/3	381	7.51
		393.64 μ c	73/9	131	1.10
		456.90 μ c	74/2	376	5.53
	48	880.50 μ c	40/11	224	2.48
		1320.75 μ c	41/13	217	1.60
		1761.00 μ c	44/9	205	2.10
		Control	46/18	372	4.55
		126.69 μ c	76/25	221	2.32
		514.01 μ c	78/19	207	0.87
	72	880.50 μ c	48/6	451	5.35
		1320.75 μ c	49/14	455	4.80
		1761.00 μ c	51/17	140	0.30

*Soaked in distilled water.

C.4.2.10. *Fruit and seed yield in the selections*

Table 50 gives the yield of fruits and seeds in the best plants of controls and treatments which are in P_1 generation during the year, in Rai 5 and Brown Sarson.

It will be seen from the table that in Rai 5 control dry seeds gave 526 fruits and 12.50 gms. of seeds. The respective figures in control 24 hours are 820 and 13.48 i.e. more than the control dry seeds. All the selections in radio-phosphorus treatment gave lesser fruits and seed yield than the control 24 hours. In 48 hours duration the treatments 126.69, 379.38, 514.01, 880.50, 1320.75 and 1761.00 μ c gave 398, 206, 228, 180, 363, and 375 fruits respectively as against 338 fruits of control. The treatments 126.69, 379.38, 880.50 and 1761.00 μ c only gave higher seed weight of 5.95, 2.47, 4.52 and 4.85 gms. respectively as against 2.37 gms. of control, which are specially interesting in 379.38 and 880.50 μ c treatments where the yields of fruits are lower than the control. In 72 hours duration the best plant in the control gave 670 fruits and 7.40 gms. of seeds. Although only the best plant in 880.50 μ c treatment gave 675 fruits i.e. higher than the control, all the selections in all the treatments gave lower seed weight than the control, which, within the treatments, weigh more in 880.50 and 1320.75 μ cs'.

In Brown Sarson the best plant in the control dry seeds gave 207 fruits and 0.60 gms. of seeds. The relative figures in control 24 hours treatment are 366 and 5.35. Although the treatments 880.50 and 1320.75 μ c, gave higher yield i.e. 409 and 467 fruits respectively, as against 366 of control, the higher yield of seed i.e. 6.30 gms. has been obtained in 456.90 μ c treatment. The rest of the treatments gave lower yield than the control. In 48 hours duration, control gave 319 fruits and 4.87 gms. of seeds. The higher yields of fruits and seeds have been obtained in 123.69 and 456.90 μ c treatments, which in the former are 381 fruits and 7.51 gms. and in the latter are 376 and 5.53. The rest treatments gave lower yield of fruits and seeds. In 72 hours duration, the best plant in the control gave 372 fruits and 4.55 gms. of seeds. The relative figures in two of the five treatments i.e. in treatments 880.50 and 1320.75 μ c, giving higher number of fruits and greater seed weight are, 451 and 5.35 in the former and 455 and 4.80 in the latter. The rest, however, gave low yields as compared to control.

C.4.2.11. *Dates of flowering and durations in the selections*

Table 51 gives the flowering behaviour of control and the selections of three treatments, 880.50, 1320.75, 1761.00 μ cs in Rai 5 and Brown Sarson, which are in P_1 generation during the year.

It will be seen from the above table that in Rai 5 except in treatment 1761.00 μ c/48 hours, where the flowering is earlier by 3 days, as against the control, all the other treatments show lateness varying from 1 to 4 days. On the other hand, although the selections in the treatments 1761.00 μ c/48 hours and 1320.75 μ c/72 hours show longer flowering period than their respective controls, all the treatments and the controls of durations 24, 48 and 72 hours complete their flowering in less time than the control dry seeds.

TABLE 51

Type and Locality	Dry and Duration in hours	Control* and Total Activity	Date of sowing	Date of 1st flowering	Age at the time of 1st flowering	Earliness and Lateness in days	Date on which last plant flowered	Age at the time of last flowering in days	Duration of flowering in days
Rai 5 (W. Bengal)	24	Control	10-12-56	16-1-57	38	—	14-2-57	67	30
		Control	"	16-1-57	38	—	11-2-57	64	27
		880.50 μ c	"	17-1-57	39	1 day late	8-2-57	61	23
		1320.75 μ c	"	17-1-57	39	1 " "	11-2-57	64	26
	48	Control	10-12-56	18-1-57	40	2 days late	6-2-57	59	20
		Control	11-12-56	18-1-57	39	—	7-2-57	59	21
		880.50 μ c	"	21-1-57	42	3 days late	7-2-57	59	18
		1320.75 μ c	"	20-1-57	41	2 days late	7-2-57	59	19
		1761.00 μ c	"	15-1-57	36	3 days early	8-2-57	60	25
	72	Control	12-12-56	22-1-57	42	—	7-2-57	58	17
		880.50 μ c	"	25-1-57	45	3 days late	11-2-57	62	17
		1320.75 μ c	"	23-1-57	43	1 day late	11-2-57	62	19
		1761.00 μ c	"	26-1-57	46	4 days late	6-2-57	57	12
Brown Sarson (E. Punjab)	24	Control	10-12-56	23-1-57	45	—	9-2-57	62	18
		Control	"	23-1-57	45	—	9-2-57	62	18
		880.50 μ c	"	23-1-57	45	same	8-2-57	61	17
		1320.75 μ c	"	23-1-57	45	"	7-2-57	60	16
	48	Control	10-12-56	23-1-57	45	"	7-2-57	60	16
		Control	11-12-56	25-1-57	46	—	7-2-57	59	14
		880.50 μ c	"	24-1-57	45	1 day early	7-2-57	59	15
		1320.75 μ c	"	26-1-57	47	1 day late	6-2-57	58	12
		1761.00 μ c	"	17-1-57	38	8 days early	6-2-57	58	21
	72	Control	12-12-56	25-1-57	45	—	5-2-57	56	12
		880.50 μ c	"	26-1-57	46	1 day late	6-2-57	57	12
		1320.75 μ c	"	27-1-57	47	2 days late	7-2-57	58	12
		1761.00 μ c	"	27-1-57	47	2 days late	5-2-57	56	10

*Soaked in distilled water.

In Brown Sarson also, like Rai 5, the treatment 1761.00 μ c/48 hours shows earliness in flowering of 8 days over its control. However, another treatment, 880.50 μ c of the same duration shows earliness of 1 day over its control. The selections in treatments of 24 hours duration flowered on the same day as the control, while the treatment 1320.75 μ c/48 hours and all the treatments of 72 hours are late by 1 to 2 days over their respective controls. The flowering period in all the treatments, except in treatment 1761.00 μ c/48 hours, is shorter than their respective controls and control dry seeds, which in the above treatment is later by 7 days than its control.

G.4.2.12. Pollen size and sterility

Table 52 gives the size of pollen grains in the control and treatments of Rai 5 and Brown Sarson, which are in P₁ generation during the year under report.

TABLE 52

Type and Locality	Generation	Dry and Duration in hours	Control* and initial Activity	Pollen diameter in μ
Rai 5 (W. Bengal)	P ₁	Dry	Control	25.43
		24	Control	25.82
		"	514.01 μ c	26.90
		"	880.50 μ c	27.77
	P ₁	48	Control	26.43
		"	126.69 μ c	27.60
		"	514.01 μ c	27.38
		"	880.50 μ c	27.77
		"	1320.75 μ c	27.85
		"	1761.00 μ c	27.81
	P ₁	72	Control	25.99
		"	126.69 μ c	27.69
		"	379.38 μ c	25.97
		"	514.01 μ c	27.76
		"	880.50 μ c	28.08
		"	1320.75 μ c	27.42
		"	1761.00 μ c	26.83
Brown Sarson (E. Punjab)	P ₁	24	Control	23.00
		"	126.69 μ c	25.82
		"	379.38 μ c	25.90
		"	514.01 μ c	25.97
		"	880.50 μ c	23.09
		"	1761.00 μ c	25.66
	P ₁	48	Control	23.01
		"	379.38 μ c	25.52
		"	514.01 μ c	25.08
		"	880.50 μ c	24.34
		"	1320.75 μ c	24.57
		"	1761.00 μ c	23.79
	P ₁	72	Control	24.02
		"	126.69 μ c	25.90
		"	379.38 μ c	25.93
		"	514.01 μ c	25.70
		"	880.50 μ c	24.49
		"	1320.75 μ c	24.41
		"	1761.00 μ c	25.23

* Soaked in distilled water.

It will be seen from the table that in Rai 5 in the control dry seeds, the pollen diameter is 25.43 μ . In all the controls and treatments of durations 24, 48 and 72 hours, the pollen diameter is more than that of the control dry seeds. Again all the radio-phosphorus treatments in these durations show slight increase in pollen diameter over their respective controls.

In Brown Sarson like Rai 5, the pollen diameter in all the radio-phosphorus treatments shows slight increase over their respective controls.

Table 53 gives the percentage of sterile pollen grains in controls and radio-phosphorus treatments (P^{32}) of Rai 5 and Brown Sarson which are in P₁ generation during the year under report.

TABLE 53

Type and Locality	Generation	Duration in hours	Control* and initial Activity	Percentage of sterile pollen grains
Rai 5 (W. Bengal)	P ₁	Dry	Control	2.29
		24	Control	3.40
		"	880.50 μ c	3.20
		"	1320.75 μ c	3.40
	P ₁	"	1761.00 μ c	5.30
		48	Control	5.40
		"	880.50 μ c	3.40
		"	1320.75 μ c	4.32
Brown Sarson (E. Punjab)	P ₁	Dry	Control	2.55
		24	Control	2.92
		"	880.50 μ c	5.55
	P ₁	48	Control	2.80
		"	880.50 μ c	6.76
		"	1320.75 μ c	4.70

*Soaked in distilled water.

It will be seen from the table that the percentage of sterile pollen grains in Rai 5 control dry seeds is 2.29. It is interesting to note that in all the treatments of 24 and 48 hours duration the percentage of sterile pollen grains is equal or less than the control.

In Brown Sarson, like Rai 5, in all the treatments of 24 and 48 hours duration, the percentage of sterile pollen grains is higher than the control and remarkably so in 880.50 μ c/48 hours treatment where it is 6.76 percent as against 2.80 percent of its control.

C.4.2.13. Cytological investigations

Cytological studies were carried out in all the Mustard types under experimentation and in white flowered mutant following X-irradiation. The dosages given were 30,000, 40,000 and 50,000 r. Common irregularities met with are false association and clumping, extrusion, early separation of bivalents, persistence of nucleolus like body through various stages of meiosis and the formation of micronucleus.

Cytological studies were also made of Mustard types Rai 5 and Brown Sarson, which were treated with beta radiations from radioactive sulphur (S³⁵) and phosphorus (P³²) and were in S₁ and P₁ generations respectively, during the current year. Besides the types of aberrations recorded with X-rays, the formations of chromatid bridges have also been encountered.

C.4.2.14. Genetical investigations

Progenies of the tall plants (two tall plants isolated in Brown Sarson 100 m.a.H. treatment in the X₃ generation in 1955) were all tall plants and varied, in leaf size and shape and pigmentation of the stem, from control and 100 m.a.H. Brown Sarson population. Cytology and yield behaviour of the same are under investigation. Expression of parental characters in the F₂ and F₃ generations of various crosses have also been recorded. Based

on the nature of the seed coat, control Brown Sarson seeds were grouped into two classes. Difference in root systems and the yield of seeds have been noted in the progenies of these two classes.

C.4.3. *Radiation mutation in Jute using X-rays and beta radiations from P^{32} and S^{35} .*

X-RAYS

During the year under report, no fresh irradiations were given to jute seeds, but the mutants and/or the promising plants which were obtained earlier, were grown along with their respective controls at Shyamnagar and Falta Experimental Stations.

C.4.3.1. *Yield trials of previous mutants*

In order to study the yields of fibre and wood, heights and basal diameters of plants and weights of green plants, a varietal trial with three varieties of *Corchorus olitorius* L., viz., Chinsura Green (C. G.), R-26 and Tall Mutant (T.M.) was conducted at the Falta Experimental Station. For this, a randomised block design with six replications was laid out. Each replication consisted of three plots and the net area of each plot was 15 ft. $\times$ 12 ft.

The mean yields of dry fibre, dry wood, weights of green plants, mean height and basal diameter of plants, together with the standard error and critical difference, are shown in Table 54.

TABLE 54
MEAN YIELDS, HEIGHT, BASAL DIAMETER, S. E. AND C. D.

Variety	Dry fibre pound/plot	Green plant pound/plot	Dry wood pound/plot	Mean height (in ft.)	Mean basal diameter (100 inches)
Tall Mutant	2.6	55	6.8	7.8	37.3
Chinsura Green	2.4	47	6.4	7.3	34.7
R-26	1.8	44	5.8	6.9	34.0
S. E.	0.08	1.81	0.22	0.10	0.73
C. D. at 5%	0.25	5.71	0.68	0.32	2.30
C. D. at 1%	0.36	8.12	0.97	0.45	3.27

It may be seen from Table 54 that the yield of dry fibre in T.M. is significantly higher (at 1% level) than R-26. The weight of green plants in T.M. is significantly more than R-26 and C. G. at 1% and 5% levels respectively. T.M. has also yielded more dry wood than R-26, the difference, once again, being significant at 1% level. The differences noticed between T.M. and R-26 with regard to the height and basal diameter of plants are significant at 1% level; but when T.M. is compared to C.G. significant difference (at 1% level) is seen only with regard to the height of plants.

It may be mentioned here that due to late sowing, the plants did not attain their normal heights and consequently the yield was also low.

C.4.2.3. Early flowering types

Mean time of flowering (in days). The behaviour of early flowering types which were obtained after X-ray irradiation on the seeds of T.M., R-26 and C.G. during the years 1947-1953 and grown in subsequent years without any further treatment, was studied. During the year under report, the selections made in the first two varieties were very promising. The mean time of flowering (in days) with standard error for the different selections and for their respective controls are given in Table 55.

TABLE 55
MEAN TIME OF FLOWERING (IN DAYS) AND STATISTICAL COMPARISON BETWEEN CONTROL AND SELECTIONS

Varieties and Selections	No. of plants observed	Mean $\pm$ S.E.	t-test
<i>Tall Mutant</i>			
Control	93	153.1 $\pm$ 0.66	
32/69(50)	96	128.7 $\pm$ 1.01	20.16*
29/30(50)	98	128.5 $\pm$ 0.84	22.99*
32/37(50)	98	132.7 $\pm$ 0.97	17.44*
21/21(48)	98	131.9 $\pm$ 0.77	20.99*
<i>R-26</i>			
Control	98	147.5 $\pm$ 0.59	
24/6 (47)	97	126.6 $\pm$ 0.83	20.49*
8/31(53)	98	116.2 $\pm$ 1.03	26.30*

*indicates significant at 0.1% level.

It will appear from Table 55, that all the selections of T.M. and R-26 flowered earlier than their respective controls. In the variety T.M., the maximum earliness of 24.6 or 25 days over the control was observed in the selection No. 29/30 (50) and in R-26, the maximum earliness was found to be 31.3 or 31 days in the selection No. 8/31(53). It may also be seen from the same table that the differences observed among the control and the selections with regard to the mean time of flowering were significant at 0.1% level.

It may be mentioned here that if the earliness in flowering in jute can be induced at a very early date and in a large number of plants, it will prove to be economical, as immediately after flowering the stems of all the plants bifurcate and both the branches grow more or less to the same height. During the usual harvest time it was observed that the plants which flowered very early in the season, could also be retted as in other cases. Due to the bifurcation of the stem, following flowering, it is expected that even if these plants do not attain the similar heights as control plants, they will have more green plant matter than the control plants and may yield more fibre. Moreover, as these plants started flowering very early in the season, some quantity of seed can also be obtained from the same plants. With these points in view, arrangements for a varietal trial have already been made. The physical and chemical nature of the fibres obtained from these early types will be tested later.

BETA RADIATIONS FROM PHOSPHORUS 32

(1) P_1 generation

The radiophosphorus used in this experiment was obtained from British Atomic Energy Commission, Harwell, England as carrier free $Na_2HP^{32}O_4$ solution in dilute hydrochloric acid (pH 2-3).

Dry selfed seeds of T.M., R-26 and C.G. belonging to *C. olitorius* and D 154 belonging to *C. capsularis*, were first kept immersed in phosphate buffer (pH 7) for 6 hours. After removing the superficial phosphate solution, the seeds were kept immersed in $2\mu c$, $20\mu c$, $200\mu c$ and 2 mc initial activity of P^{32} for 4, 12, 24 and 48 hours. The control seeds were kept immersed in phosphate buffer for the same period. After the specified hours of treatments, the treated seeds were washed in running water to remove the superficial isotope and buffer solutions and sown at the Shyamnagar Experimental Station, with a spacing of 1.50 ft. between the rows and 0.50 ft. between the plants.

During the period under report, considerable damage was caused to the jute plants due to heavy rains and flood and hence the heights and basal diameters recorded were below normal.

C.4.3.3. Percentage of survival

The mean percentage of the surviving plants for the different treatments are shown in Table 56-a-d.

TABLE 56
MEAN PERCENTAGE OF SURVIVAL FOR DIFFERENT COMBINATIONS OF *C. olitorius*
VARIETIES (a-c).

(a) Treatment $\times$ Duration

Treatment Duration	Control	$2\mu c$	$20\mu c$	$200\mu c$	2mc	Mean
4 hrs.	17.6	28.2	21.7	13.5	13.3	18.9
12 hrs.	21.6	22.2	19.4	19.9	28.2	22.2
24 hrs.	26.5	24.3	28.1	15.9	23.7	23.7
48 hrs.	12.9	15.2	14.9	14.3	17.1	14.9
Mean	19.7	22.4	21.0	15.9	20.6	19.9

(b) Variety $\times$ Duration

Variety Duration	T.M.	C.G.	R-26	Mean
4 hrs.	26.9	9.7	20.0	18.9
12 hrs.	19.9	13.2	33.7	22.2
24 hrs.	22.6	20.1	28.4	23.7
48 hrs.	9.2	22.2	13.3	14.9
Mean	19.6	16.3	23.8	19.9

Table 56 (contd.)

(c) Variety $\times$ Treatment

Variety Treatment				
	T.M.	C.G.	R-26	Mean
Control	19.7	14.8	24.6	19.7
2 μ c	21.1	16.1	30.2	22.4
20 μ c	20.0	18.7	24.4	21.0
200 μ c	15.0	12.9	19.8	15.9
2mc	22.4	19.0	20.2	20.6
Mean	19.6	16.3	23.8	19.9

(d) Percentage of survival for D-154

Treatment	Control	2 μ c	20 μ c	200 μ c	2mc	Mean
Duration						
4 hrs.	29.8	45.1	40.5	44.4	43.4	40.6
12 hrs.	34.3	23.9	21.7	20.0	8.3	21.0
24 hrs.	24.2	18.0	16.1	11.7	18.0	17.4
48 hrs.	25.1	25.4	8.8	20.5	18.0	19.1
Mean	28.3	27.6	20.7	23.2	20.7	24.0

On statistical analysis it was found that there were significant differences between the varieties and the durations of treatments. The interaction between varieties and durations was highly significant, indicating thereby that the behaviour of the different varieties differs for a particular dose and duration of treatment. In R-26, 23.8% of plants survived till maturity and when compared to T.M. and C.G., significant differences were found from C.G. only, where only 16.3% of plants survived till maturity.

Regarding the duration of treatment, it was noted that when the seeds were treated for 48 hours, there was a fall in the number of surviving plants.

In the variety D 154 also, significant variation was noticed in the percentage of survival in the different durations (Table 56 d). The maximum percentage of surviving plants was found when the seeds were treated for the minimum time i.e., for 4 hours and when compared to the three remaining durations, significant differences were noted on statistical analysis.

The differences observed among the activities of radioisotopes used in the present experiment were not statistically significant.

C.4.3.4. Heights of plants

During the harvest time, all the plants were measured for determining the maximum heights attained by the individual plants. The results of the statistical analysis on the mean height of plants in feet, are given in Table 57.

TABLE 57

MEAN HEIGHTS OF PLANTS (IN FEET)

Tall Mutant

Treatment	Duration				Mean
	4 hrs.	12 hrs.	24 hrs.	48 hrs.	
Control	9.0	7.4	7.2	6.4	7.5
2 μ c	9.5	8.4	7.3	6.3	7.5
20 μ c	8.3	8.0	6.5	6.1	7.3
200 μ c	8.7	7.8	6.7	6.4	7.4
2mc	8.4	7.2	6.4	6.1	7.0
Mean	8.8	7.5	6.8	6.3	

S. E. for the body of the table = 0.45

S. E. for the duration = 0.25

S. E. for the treatment = 0.21

It may be seen from Table 57 that in the varieties R-26 and C.G., the differences seen in the various treatments, duration and the interaction of treatment and duration, were significant at 1% level, while in the varieties T.M. and D 154, only the duration showed significant differences at 1% and 5% levels respectively.

In T.M. it was observed that with increase in the duration of treatment there was decrease in the mean heights of plants. On the other hand, in D 154, increase in the mean heights of plants was observed with increase in the duration of treatment.

MEAN HEIGHTS OF PLANTS (IN FEET)

R-26

Treatment	Duration				Mean
	4 hrs.	12 hrs.	24 hrs.	48 hrs.	
Control	9.8	4.8	5.8	5.0	6.3
2 μ c	10.2	5.6	6.6	4.5	6.7
20 μ c	9.8	5.3	7.2	4.6	6.7
200 μ c	7.2	5.4	6.5	4.8	6.0
2mc	6.1	4.7	5.4	4.9	5.3
Mean	8.6	5.2	6.3	4.8	

S. E. for the body of the table = 0.41

S. E. for the duration = 0.23

S. E. for the treatment = 0.19

MEAN HEIGHTS OF PLANTS (IN FEET)
Chinsura Green

Treatment	Duration				Mean
	4 hrs.	12 hrs.	24 hrs.	48 hrs.	
Control	5.1	6.0	5.6	4.6	5.4
2 μ c	8.2	5.2	5.5	5.8	6.3
20 μ c	6.7	5.8	4.9	6.4	5.8
200 μ c	5.7	5.4	4.8	6.7	5.8
2mc	6.3	5.2	4.9	4.4	5.2
Mean	6.4	5.5	5.2	5.6	

S. E. for the body of the table = 0.28

S. E. for the duration = 0.14

S. E. for the treatment = 0.13

MEAN HEIGHTS OF PLANTS (IN FEET)
D-154

Treatment	Duration				Mean
	4 hrs.	12 hrs.	24 hrs.	48 hrs.	
Control	6.0	6.1	6.4	6.9	6.3
2 μ c	6.5	6.1	6.9	6.9	6.4
20 μ c	6.4	6.3	7.0	6.9	6.7
200 μ c	5.9	6.6	7.0	6.7	6.6
2mc	5.7	6.8	6.7	6.9	6.5
Mean	5.9	6.4	6.8	6.9	6.5

S. E. of the body of the table = 0.46

S. E. of the duration = 0.24

S. E. of the treatment = 0.22

C.4.3.5. Flowering Behaviour

All the plants were studied with reference to the time taken for first flowering in the control and the treated populations of the four varieties of jute under investigation. The mean time of flowering (in days) with standard error, is given in Table 58.

TABLE 58
MEAN TIME OF FLOWERING (IN DAYS) WITH S. E. FOR DIFFERENT VARIETIES
Tall Mutant

Treatment	Duration				Average
	4 hrs.	12 hrs.	24 hrs.	48 hrs.	
Control	154.4 $\pm$ 0.61	149.6 $\pm$ 0.81	151.6 $\pm$ 0.57	164.2 $\pm$ 1.12	153.1 $\pm$ 0.35
2 μ c	154.7 $\pm$ 0.47	151.0 $\pm$ 0.66	149.7 $\pm$ 0.81	162.4 $\pm$ 0.66	153.8 $\pm$ 0.32
20 μ c	154.8 $\pm$ 0.53	150.4 $\pm$ 0.64	151.2 $\pm$ 0.72	163.6 $\pm$ 0.78	153.5 $\pm$ 0.33
200 μ c	153.8 $\pm$ 0.53	149.3 $\pm$ 0.74	151.2 $\pm$ 0.89	162.8 $\pm$ 1.22	153.2 $\pm$ 0.38
2mc	154.7 $\pm$ 0.59	151.2 $\pm$ 0.61	152.7 $\pm$ 0.48	163.0 $\pm$ 0.69	154.3 $\pm$ 0.29
Average	154.5 $\pm$ 0.24	150.4 $\pm$ 0.31	151.6 $\pm$ 0.29	163.1 $\pm$ 0.33	153.6 $\pm$ 0.15

TABLE 58 (Contd.)
MEAN TIME OF FLOWERING (IN DAYS) WITH S. E. FOR DIFFERENT VARIETIES

R-26					
Duration	4 hrs.	12 hrs.	24 hrs.	48 hrs.	Average
Treatment					
Control	126.6±0.89	137.5±0.79	129.2±1.07	145.8±0.97	133.1±0.49
2 μ c	120.7±0.87	134.2±0.77	130.2±0.88	143.6±0.67	130.1±0.43
20 μ c	121.1±0.62	134.2±1.37	126.8±0.88	142.0±1.04	129.2±0.48
200 μ c	122.6±1.49	135.3±0.84	127.8±1.25	144.0±1.32	132.2±0.59
2mc	123.8±2.05	135.6±0.72	129.0±1.43	141.8±1.14	134.5±0.55
Average	122.7±0.44	135.5±0.38	128.6±0.47	143.3±0.45	131.8±0.22

Chinsura Green					
Duration	4 hrs.	12 hrs.	24 hrs.	48 hrs.	Average
Treatment					
Control	*151.2±2.42	135.9±1.03	140.0±1.58	143.6±0.97	140.4±0.66
2 μ c	132.4±1.04	135.0±1.80	145.1±1.14	135.3±1.08	137.6±0.60
20 μ c	137.6±1.23	136.9±1.24	143.4±0.90	138.9±1.21	140.0±0.56
200 μ c	141.0±2.85	139.0±1.92	145.8±1.38	136.1±0.91	139.5±0.69
2mc	141.7±1.29	137.6±1.13	144.1±1.01	145.1±0.72	142.7±0.49
Average	137.5±0.65	136.8±0.58	143.7±0.52	140.0±0.43	140.2±0.26

* Average figure is based on 10 plants.

D-154					
Duration	4 hrs.	12 hrs.	24 hrs.	48 hrs.	Average
Treatment					
Control	127.8±1.00	125.8±0.80	124.9±0.67	122.1±0.67	125.3±0.41
2 μ c	126.6±0.78	128.3±0.94	123.0±0.66	120.8±0.74	125.1±0.42
20 μ c	124.8±0.64	126.3±0.88	121.1±0.87	121.1±0.99	124.1±0.42
200 μ c	125.2±0.71	125.2±0.91	120.8±1.15	123.1±0.58	124.2±0.42
2mc	126.6±0.66	124.9±1.44	122.8±1.13	122.1±0.80	124.7±0.46
Average	126.1±0.34	126.3±0.44	122.9±0.39	121.9±0.39	127.3±0.19

From Table 58, it will be seen that the variety D 154 is the earliest. It flowered earlier than T.M., C.G. and R-26 by 26, 13 and 5 days respectively.

In the variety T.M., the mean time of flowering for different treatments as well as for the control was practically the same, but significant differences were observed in the different durations of treatments. Compared to the first three durations, the flowering in the 48 hours duration was delayed by about 9—11 days but the differences among 4 hours, 12 hours and 24 hours treatments were not very marked.

A similar behaviour was also observed in the variety R-26 where the range of variation was only 4—5 days. When compared to the plants in the 4 hours duration, the plants

in the other three durations i.e., 12, 24 and 48 hours, flowered late by 13, 6 and 20 days respectively.

Like T.M. and R-26, the average time of flowering in different treatments and control in the variety C.G. varied upto 5 days. Unlike the first two varieties, no marked differences were seen between 4 hours and 48 hours durations. The difference between 4 hours and 12 hours is negligible, but when compared to the first two durations the flowering in 24 hours duration was delayed by 6-7 days.

C.4.3.6. Bifurcation of plants

In the treated population of the three olitorius varieties, there were a large number of plants showing bifurcation of stem, from the ground level or very near to it, when their respective control plants had one erect stem. Table 59 gives the percentage of plants showing bifurcations in the different durations of treatment with 2 mc initial activity of P^{32} .

TABLE 59

PERCENTAGE OF PLANTS SHOWING BIFURCATION
INITIAL ACTIVITY OF $P^{32} = 2 \text{ mc}$

Variety Duration			
	T.M	C.G.	R-26
4 hrs.	0	2.0	0
12 hrs.	17.2	4.2	8.1
24 hrs.	21.9	20.0	20.6
48 hrs.	48.4	34.4	37.8

It will be seen from table 59 that in all the three varieties viz., T.M., R-26 and C.G., with increase in duration, there is increase in the number of plants showing bifurcations.

It may also be seen that in the variety T.M., there was as high as 48.4% of plants showing bifurcation in the 48 hours treatment. In the same duration, R-26 and C.G. had 37.8% and 34.4% respectively.

C.4.3.7. Morphological abnormalities

(i) From the very beginning several of the treated plants had poor growth and the internodes were very short, giving a stunted appearance to the plants, with leaves crowding at the top. The leaves showed various types of forking, starting from forking of the tip into two or three to two completely free leaves on one petiole. In extreme cases, the petioles were also divided.

(ii) Epiascidia developed from the stem in place of a normal leaf or it was also found to appear from the under surface of a normal leaf and remaining united to the base of the lamina with the end of the stalk of the ascidium.

Anatomical studies of the stalk of these foliar ascidia at the very base show a central vascular bundle with a narrow pith. The vascular bundle is closed collateral, with phloem towards the periphery. About the middle of the stalk, the vascular bundle becomes nar-

rower and compressed. The pith cells are obliterated and replaced by some narrow elements of xylem. The vascular bundle begins to widen and narrow strips of pith cells are found towards the apical region of the stalk. The vascular tissue now becomes horse-shoe shaped from the semilunar type. One arm of the vascular tissue appears longer and divided into at least two unequal vascular masses. The smaller one gradually recedes from the larger vascular bundle and ultimately forms the first branch rib of the ascidium. Similarly, the other arm of the vascular bundle divides and the second smaller vascular mass forms another rib of the cup. This is situated on the opposite side of the first branch rib. The median vascular mass forms the mid-rib of the ascidium. The xylem of the mid-rib and the secondary ribs lie towards the palisade and the phloem towards the spongy tissue side of the cup.

Fasciation and coiling of the stem, a pair of leaves appearing back to back on a petiole and remaining united upto 1/3rd the length of lamina from the base, were noted in some of the treated plants.

Anatomical studies of these specimens are in progress.

Attempts have also been made to induce germinal mutation by injecting P^{32} and S^{35} solutions at the base of the flowers and subsequently using the pollen grains from these plants in crossing experiments with normal plants.

(2) P_2 generation

C.4.3.8. Important features of P_2 generations

In the P_2 generation, the flowering behaviour of early types selected during the previous year was found to be very promising. Table 60 shows the mean time of flowering (in days) for different selections and the comparison between control and selections.

TABLE 60
MEAN TIME OF FLOWERING (IN DAYS) FOR DIFFERENT SELECTIONS
AND STATISTICAL COMPARISON BETWEEN CONTROL AND
SELECTIONS

Date of sowing 10.5.1956			
Variety Selection	No. of plants studied	Mean time of flowering $\pm$ S.E.	t-test
Tall Mutant			
Control	44	138.9 $\pm$ 1.25	
T.M./1P/55	45	121.0 $\pm$ 1.08	10.85*
T.M./2P/55	48	120.8 $\pm$ 0.76	12.40*
T.M./3P/55	47	126.4 $\pm$ 1.68	5.98*
R-26			
Control	44	124.4 $\pm$ 1.30	
R-26/1P/55	49	103.1 $\pm$ 0.94	13.31*
R-26/2P/55	47	108.6 $\pm$ 1.21	8.88*
R-26/3P/55	50	109.1 $\pm$ 1.35	8.18*

*Indicates 0.1% level of significance

It will be seen from Table 60 that the selections in the varieties T.M. and R-26 flowered earlier than their respective controls which were significant at 0.1% level. It may be mentioned here that all the selections in T.M. flowered earlier in their P_1 generation and these were continued in P_2 . In R-26, the first two selections were late in flowering in P_1 , but they were found to be promising in P_2 , being earlier than their control and significant at 0.1% level.

Abnormalities in leaf shape and size were noticed in many plants in their P_2 generation when their P_1 plants did not show any variation in the previous year. Particular mention may be made of irregular development of wings, spoon shaped leaf, forking of leaf tip and petioles, crinkled leaves etc.

G.4.3.9. *Inheritance studies of aberrant plants*

Suitable crossing experiments were carried out in order to study the inheritance of abnormal plants obtained after irradiation with P^{32} , during 1955-56 and 1956-57. Successful crosses were grown during the period under report and the segregation ratios noted. Plants showing fasciation for coiling did not exhibit these peculiarities in the F_1 and generations. Even the selfed seeds from such plants developed into normal plants.

Plants grown from P^{32} treated seeds of R-26 which appeared as T.M. in the year 1955-56 with regard to the colour of the stem and leaves were backcrossed with normal R-26 plants and the hybrid plants segregated into 39 T.M. and 37 R-26 plants or roughly 1 : 1 ratio and when selfed and grown in the next generation, the colour segregated into monohybrid ratio. Hence it indicates that the T.M. like plants obtained in the P_1 generation was in a dominant heterozygous state.

In G.G., one plant with crinkled leaves was isolated in X_3 generation in 1955-56 season and on selfing it was found to be breeding true during the year under report.

G.4.4. *Irradiation and Cytogenetical studies in Tomato* (*Lycopersicon esculentum* L).

Further studies were conducted during the year, on "Tezier Prim", the same variety experimented during the previous year. From the treated progenies of the previous year with X-rays and ultraviolet rays on dry and germinated seeds, new variants were isolated in the second generation. Fresh treatments made during the year include X-rays up to 56,000 r and different activities and durations of S^{35} and P^{32} . Detailed cytological studies were also completed.

(a) X-RAYS— X_1 GENERATION

Fresh irradiations with X-rays were done during the year under report on dry and 48 hours soaked seeds with 2,000 r, 4,000 r, 8,000 r, 16,000 r, 24,000 r, 32,000 r, 40,000 r, 48,000 r and 56,000 r. In the treatments with the presoaked seeds, there were no germinations above 24,000 r and at 24,000 r and at 16,000 r, the seeds germinated but the seedlings died at different stages before maturity. In the dry seed treatments, germinations were greatly reduced at 56,000 r and the plants did not grow to maturity.

C.4.4.1. *Height of plants, yield etc.*

In the first generation of the treated populations with X-rays on dry and germinated seeds, the yield was recorded by taking the weight of all the fruits on the individual plants. Certain individual plants in the treatments gave better yield than their controls. Table 61 shows the yield of the best plants in comparison with the average yield of a plant in each population and the shoot size of the best yielder, in comparison with the mean plant size of the population. The relative weights of the fruits in treatments were calculated on the basis of 100 gms. in the controls.

TABLE 61

Serial No.	Control Dry and germinated seed	4,000 r Dry seed	8,000 r Dry seed	16,000 r Dry seed	4,000 r germinated seed	8,000 r germinated seed
1. Relative weights of the fruits in gms., in the highest yielding plant	100	140	130	100	66½	80
2. Height of the main shoot of the highest yielder	34"	39"	45"	28"	34"	42"
3. No. of branches of the highest yielder	10	11	10	8	9	6
4. Average length of a branch in the highest yielder	15.1"	19"	17.8"	13"	15"	23"
5. Total length of the shoot in highest yielder	185"	248"	223"	182"	169"	180"
6. Relative mean yield per plant (wt. in gms) (40-50 plants)	100	84	83	66	72	101
7. Mean height of the main shoot per plant (40-50 plants)	33.6"	30.1"	31.2"	30.4"	30.14"	32.1"
8. Mean number of branches per plant (40-50 plants)	7.46	5.66	6.16	6.37	7.3	7.28
9. Mean length of a branch per plant (40-50 plants)	18.12"	15.92"	16.53"	16.37"	17.3"	16.87"
10. Mean length of a shoot per plant (40-50 plants)	168.7"	120.2"	133.0"	134.7"	156.4"	155.6"

It was noted from the above table that in general in the first generation, the yield was directly proportional to the size of the plant—the bigger the plants, the higher the yield. The best plants in the treatments had a greater fruit weight than the best plants in the respective controls. Progenies were raised during the second generation from the highest

yielder of the previous year from 4,000 r and 8,000 r treatments on dry seed, during the year under report.

Early flowering selections were made in 8,000 r treatment on dry and germinated seeds which were 6 and 15 days earlier, respectively over the controls. Another early flowering selection made from 4,000 r on germinated seed showed 6 days earliness. Progenies from some of the early flowering and also late flowering X_1 plants were raised to study their behaviour in X_2 generation. In general, it was found that early selections had lesser yields.

(b) ULTRAVIOLET RAYS

In the first generation, ultraviolet treatment did not give any encouraging results from the economic point of view. However, the second generation was raised to study their yield and time of flowering, and to isolate recessive morphological mutants, if any.

C.4.4.2. Pollen sterility

The studies on the pollen sterility was made from 8 to 10 plants of the population; The details are given in Table 62. Treatments with X-rays on dry seeds induced greater pollen sterility than on germinated seeds. The maximum pollen sterility was seen at 4,000 r and further doses decreased the pollen sterility. In germinated seed treatments, the pollen sterilities were nearly the same as in controls.

TABLE 62

S. No.	Seed state during irradiation	Treatment	Average pollen sterility of the population
1.	Germinated seed	Control	3.4
2.	"	4,000 r	5.2
3.	"	8,000 r	4.3
4.	Dry seed	Control	3.4
5.	"	4,000 r	24
6.	"	8,000 r	11
7.	"	16,000 r	11.2

C.4.4.3. Further studies in the aberrant plants of the previous generation.

Further studies on the aberrants isolated in the X_1 generation of the previous year, were continued. The small statured X_1 plant gave rise to normal individuals in the X_2 generation. The wiry leaved mutant in X_1 generation produced two small fruits. One fruit had few small seeds, which failed to germinate, while the other fruit was seedless. The pollen sterility of this plant was 95%. A similar "wiry" mutant was isolated during the current year also, in fresh irradiations with 32,000 r on dry seeds. It had short internodes with wiry and partially developed leaf blades. Flowers were few, which did not set fruits. A similar mutant with the same behaviour has been reported earlier. The progenies grown in the X_2 generation, from an individual of the X_1 which had greater cell and stomatal sizes, were found to be normal.

In X_2 generation, a certain percentage of seeds failed to germinate, which was more in the progenies of the treated dry seeds than in the germinated seeds. This also increased with increase in dosage. The same was the case with recessive lethals, that perished during different stages. In some, the development was checked at the cotyledons or the first leaf or the second leaf or the third leaf stages. In others the development did not proceed after termination of the epicotyl into a knob or fleshy cup like structure or a fleshy leaf. One dwarf plant grew to a height of only 5 inches, developing slowly during its life time. Its two small branches had nearly 10 leaves each. The leaves were closely set, without internodes. Its small leaflets numbered 5 or 7 per frond and its leaf rachis measured 2 ins. in length and without flowers. Another dwarf grew to about 8 inches in height and had a thick stem and its leaf fronds attained the normal size. The length of the leaf rachis was slightly reduced, with the normal number of leaflets being closely set. This perished after bearing three fleshy flowers, which did not set fruits. Three plants with one of their cotyledons being sessile (cotyledonary stalk missing) were seen. Of these, only one developed further and was normal.

Individuals with bifurcated epicotyl, short hypocotyl, linear leaves associated with erect nature, were isolated. One pale green coloured plant had prominent protuberance at the stylar end in the initial stages of the fruit development, which gave rise to a bilocular berry. A fasciated plant ending in a normal shoot, had a large inflorescence with about 80 flowers, out of which only four developed into fruits.

Bushy and short internoded mutants were often seen in the second generation. Leaf fronds of these were reduced in length. Extra carpellary flowers were commonly seen on these plants, producing wrinkled and irregular shaped fruits with extra number of locules. Small axillary shoots were seen at each node.

In a progeny of 30 individuals raised from seeds of an X_1 selection for earliness with 8,000 r treatment on dry seeds, there were two normal healthy growing plants which did not set fruits. Two others were pale green and slowly developing and did not set fruit due to the development of abscission layer immediately after the flower opening. Still two others were brachytic plants. The rest were normal.

C.4.4.4. *Beta radiations from S^{35} and P^{32} .*

The treatments with S^{35} and P^{32} conducted during the year are given in Table 63. The treated plants with their respective controls were grown in the field. Controls had 100% germinations. Data were collected on the size of the cotyledon, length of the hypocotyl, survival percentage and the growth rate. In B-4 treatment in Table 63, a chimerical plant with reduced, mosaic and crinkled leaf blade between 8th to 12th leaf, was isolated.

C.4.4.5. *Cytological studies.*

Meiotic studies of the naturally occurring cleistogamous male sterile plant of the previous year, showed a break-down in meiosis immediately after regular synapsis at pachytene. This plant showed variations in the development of the tapetum and the plant morphology was greatly affected. Unfortunately fruits could not be obtained.

TABLE 63

S. No.	Date of Treatment	Treatment	No. of seeds treated	Nature of seed before treating	Isotope used	Total initial activity of the solution in μc	Average dosage per seed in μc	Duration of treatment in hours	Percentage of germinated seeds
1.	13-12-56	A-1	50	48 hrs. pre-soaked	S ³⁵	452.64	0.31	48	98
2.	"	A-2	"	"	"	"	0.47	72	80
3.	"	A-3	"	"	"	"	1.58	96	86
4.	"	A-4	"	Dry seed	"	"	0.15	48	96
5.	"	A-5	"	"	"	"	0.234	72	93
6.	"	A-6	"	"	"	"	0.786	96	80
7.	15-12-56	B 1	"	72 hours pre-soaked	P ³²	10.926	0.041	48	100
8.	"	B 2	"	"	"	24.28	0.092	48	96
9.	"	B 3	"	"	"	27.31	0.130	48	100
10.	11-12-56	B 4	"	Dry seed	"	52.33	0.445	67	63
11.	"	B 5	"	"	"	104.66	0.810	67	90
12.	"	B 6	"	"	"	150.96	1.580	67	60

Meiotic studies

Meiosis in the X-rayed plants and the controls in the dry and germinated seed treatments series were completed. Detailed studies were made from diakinesis to tetrad stage and the percentage of aberrant pollen mother cells were counted. In general, the irregularities were those affecting the spindle, but the structural types affecting chromosomes were not common. Tripolar spindles at first metaphase and second metaphase were usually seen. The majority of the irregularities consisted of bivalents, varying from 1 to 3 failing to congregate at the equator at first metaphase, which formed their own spindles and underwent the first and second divisions. Such a failure to congregate at the equator was seen at second metaphase also. Other irregularities noted were precocity in division i.e. some dividing earlier than the others and reaching the poles early or a bivalent reaching a pole without division, thus changing the number of chromosomes at the poles. Disturbed meiosis, with the univalents scattered all over the cell or forming several groups, were also found in rare cases.

Restitution nuclei, due to the inclusion of the univalents within the same nucleus at the end of the first division, were observed. These were seen undergoing the second or the equational division. In certain individual plants, cytomixis in the prophase stages and elongated and curved spindles with univalents and bivalents scattered all over the spindles, were often seen. Occasionally, cells with less than normal number of chromosomes at first metaphase, were also seen. The cells which received the chromatin matter from the adjacent cells due to cytomixis were sometimes found to organise a small additional nucleus, besides the normal nucleus. These irregularities were found resulting in polyspory i.e. with extra number of cells at tetrad stage. They were either of uniform size or of different sizes. These additional cells vary from one to five in number. Monad, diads and triads at the tetrad stage, were also not uncommon.

The plants which did not set fruits in X_2 generation showed about 90% pollen sterility and had inversion bridges and translocations.

C.4.5. *Induced mutation and Cytogenetical studies in paddy (Oryza sativa L.) using X-rays and beta radiations from radiophosphorus and radiosulphur*

Investigations on induced mutation in three aman varieties of paddy, namely *Rupsail*, *Latisail* and *Patnai*, have been made using X-rays, P^{32} and S^{35} .

For irradiations with X-rays, dry healthy seeds were kept in a single layer inside the capsule and irradiated with 5,000, 10,000, 20,000 and 40,000 r units, by means of a Philips Contact Cavity Therapy tube, running at 50 Kv and 2 mA current. Extra filters were not used.

The radioisotopes, both the P^{32} and S^{35} were obtained from British Atomic Energy Commission, Harwell, England, as $Na_2HP^{32}O_4$ and $Na_2S^{35}O_4$ respectively. Dry seeds of all the three varieties were first kept immersed in phosphate buffer (pH 7) for 24 hours. After removing the superficial buffer solution, the seeds were kept immersed in 10 μ c, 100 μ c and 1 mc initial activity of P^{32} for 24, 48 and 72 hours and in 50 μ c and 500 μ c initial activity of S^{35} for 48 and 96 hours. Control seeds were also kept immersed in phosphate buffer, for the same periods.

After the specified durations of the treatments, the seeds were washed in running water, to remove the superficial isotope and buffer solutions. The seeds were then put in the seed bed, at the Shyamnagar Experimental Station of the Bose Institute and later transplanted in the field.

C.4.5.1. *Survival of plants*

In the seed bed, observations were made on the number of plants which survived in the control and in the different treatments and the results are shown in Tables 64, 65 and 66.

TABLE 64

Treatment	Variety		
	Rupsail	Latisail	Patnai
Control	31.5	49.5	82.5
5,000 r	74.5	35.0	56.0
10,000 r	68.0	25.0	71.0
20,000 r	72.0	40.0	73.5
40,000 r	57.1	40.0	73.5

TABLE 65

RUPSAIL

Duration Treatment	24 hrs.	48 hrs.	72 hrs.
Control	80.08	87.80	82.92
10 μ c	61.77	52.58	59.11
100 μ c	52.63	69.77	59.90
1mc	70.22	33.62	78.66

LATISAIL

Control	37.77	45.53
10 μ c	69.82	69.56
100 μ c	66.22	39.16
1mc	70.22	51.75

PATNAI

Control	91.5	52.19	85.36
10 μ c	74.0	60.78	75.47
100 μ c	80.0	60.63	57.77
1mc	71.0	72.77	83.33

TABLE 66

RUPSAIL

Duration Treatment	48 hrs.	96 hrs.
Control	55.0	16.5
50 μ c	54.0	41.0
500 μ c	61.0	51.0

LATISAIL

Control	69.0	48.0
50 μ c	77.0	56.5
500 μ c	79.0	43.5

PATNAI

Control	34.5	53.0
50 μ c	14.0	58.5
500 μ c	47.5	60.5

It will be seen from Table 64 that there was heavy mortality in control seeds of Rupsail. In the other two varieties viz., *Latisail* and *Patnai*, the number of plants which survived in the controls was more than in the different X-ray treatments.

In the P^{32} treated population as will be seen from Table 65, that the control seeds of *Latisail* which were kept immersed in phosphate buffer for 24 hours, were adversely affected and the number of seedlings which survived was low. On the other hand, it was noticed that in some of the treatments viz., $10\mu\text{c}$ and 1 mc treatment for 48 hours in *Latisail*, $10\mu\text{c}$, $100\mu\text{c}$ and 1 mc treatments for 48 hours in *Patnai*, there had been an increase in the percentage of surviving plants over the control.

The S^{35} treated populations of all the three varieties as seen from Table 66, excepting the $500\mu\text{c}$ treatment for 96 hours in *Latisail* and the $50\mu\text{c}$ treatment for 48 hours in *Patnai*, had lesser mortality than their respective controls.

C.4.5.2. Flowering behaviour

All the plants both in the control and the X_1 , P_1 and S_1 populations were studied with regard to the time taken for first flowering (in days), in order to isolate early flowering mutants, if any.

It will be seen from Tables 67, 68 and 69 that there were no marked differences with regard to the time taken for first flowering in the treated populations and their respective control plants. However, an earliness of 4 days was noticed in $100\mu\text{c}$ treatment with P^{32} for 48 hours, in the variety *Latisail*.

TABLE 67

RUPSAIL

Control & Treatments	Date of sowing	Date of 1st flowering	Time taken for 1st flowering (in days)	Difference with control (in days)
Control	16.6.1956	18.10.1956	124	
5,000 r	"	18.10.1956	124	± 0
10,000 r	"	19.10.1956	125	- 1
20,000 r	"	19.10.1956	125	- 1
40,000 r	"	18.10.1956	124	± 0

LATISAIL

Control	16.6.1956	19.10.1956	125	
5,000 r	"	20.10.1956	126	- 1
10,000 r	"	19.10.1956	125	± 0
20,000 r	"	20.10.1956	126	- 1
40,000 r	"	21.10.1956	127	- 2

PATNAI

Control	16.6.1956	19.10.1956	125	
5,000 r	"	20.10.1956	126	- 1
10,000 r	"	18.10.1956	124	+ 1
20,000 r	"	20.10.1956	126	- 1
40,000 r	"	19.10.1956	125	± 0

TABLE 68

Control & Treatments	Date of sowing	Date of 1st flowering	Time taken for 1st flowering (in days)	Difference with control (in days)
Rupsail				
Control—24 hrs.	23-6-1956	18-10-1956	117	
10 μ c—24 hrs.	"	"	117	± 0
100 μ c—24 hrs.	"	"	117	± 0
1 mc—24 hrs.	"	"	117	± 0
Control—48 hrs.	26-6-1956	19-10-1956	115	
10 μ c—48 hrs.	"	18-10-1956	114	+ 1
100 μ c—48 hrs.	"	18-10-1956	114	+ 1
1 mc—48 hrs.	"	19-10-1956	115	± 0
Control—72 hrs.	26-6-1956	19-10-1956	115	
10 μ c—72 hrs.	"	"	115	± 0
100 μ c—72 hrs.	"	"	115	± 0
1 mc—72 hrs.	"	"	115	± 0
Latisail				
Control—24 hrs.	29-6-1956	22-10-1956	115	
10 μ c—24 hrs.	"	"	115	± 0
100 μ c—24 hrs.	"	"	115	± 0
1 mc—24 hrs.	"	"	115	± 0
Control—48 hrs.	30-6-1956	23-10-1956	115	
10 μ c—48 hrs.	"	22-10-1956	114	+ 1
100 μ c—48 hrs.	"	19-10-1956	111	+ 4
1 mc—48 hrs.	"	22-10-1956	114	+ 1
Patnai				
Control—24 hrs.	23-6-1956	20-10-1956	119	
10 μ c—24 hrs.	"	21-10-1956	120	- 1
100 μ c—24 hrs.	"	20-10-1956	119	± 0
1 mc—24 hrs.	"	20-10-1956	119	± 0
Control—48 hrs.	26-6-1956	18-10-1956	114	
10 μ c—48 hrs.	"	18-10-1956	114	± 0
100 μ c—48 hrs.	"	21-10-1956	117	- 3
1 mc—48 hrs.	"	21-10-1956	117	- 3
Control—72 hrs.	26-6-1956	19-10-1956	115	
10 μ c—72 hrs.	"	18-10-1956	114	+ 1
100 μ c—72 hrs.	"	18-10-1956	114	+ 1
1 mc—72 hrs.	"	18-10-1956	114	+ 1

TABLE 69

Control & Treatments	Date of sowing	Date of 1st flowering	Time taken for 1st flowering (in days)	Difference with control (in days)
Rupsail				
Control—48 hrs.	21-7-1956	24-10-1956	95	
50 μ c—48 hrs.	"	25-10-1956	96	- 1
500 μ c—48 hrs.	"	26-10-1956	97	- 2
Control—96 hrs.	23-7-1956	26-10-1956	95	
50 μ c—96 hrs.	"	26-10-1956	95	$\pm$ 0
500 μ c—96 hrs.	"	24-10-1956	93	+ 2
Latisail				
Control—48 hrs.	21-7-1956	24-10-1956	95	
50 μ c—48 hrs.	"	24-10-1956	95	$\pm$ 0
500 μ c—48 hrs.	"	24-10-1956	95	$\pm$ 0
Control—96 hrs.	23-7-1956	24-10-1956	93	
50 μ c—96 hrs.	"	24-10-1956	93	$\pm$ 0
500 μ c—96 hrs.	"	24-10-1956	93	$\pm$ 0
Patnai				
Control—48 hrs.	21-7-1956	25-10-1956	96	
50 μ c—48 hrs.	"	26-10-1956	97	- 1
500 μ c—48 hrs.	"	25-10-1956	96	$\pm$ 0
Control—96 hrs.	23-7-1956	24-10-1956	93	
50 μ c—96 hrs.	"	25-10-1956	95	- 2
500 μ c—96 hrs.	"	24-10-1956	93	$\pm$ 0

C.4.5.3. No. of ear-heads

In order to study the yield of grains per plant, investigations were first made on the number of ear-heads, since, in general, the grain yield per plant will depend upon the number of ear-heads in that. For this, ten plants were selected at random, both from the control and treated populations and the number of ear-heads per plant was counted. The mean number of ear-heads per plant with S.E. in the X_1 , P_1 and S_1 populations and their respective controls are shown in Tables 70, 71 and 72 respectively.

TABLE 70

Treatment	Variety		
	Rupsail	Latisail	Patnai
Control	13.4	19.4	12.8
5,000 r	11.7	16.4	14.7
10,000 r	12.9	16.0	14.1
20,000 r	12.2	13.9	13.1
40,000 r	11.3	14.9	14.8
S. E.	0.97	1.58	1.03

It will be seen from Table 70 that in the X-ray treatments in the varieties *Rupsail* and *Latisail* there was a decrease in the number of ear-heads, while there was slight increase

in the variety *Patnai*. On statistical analysis, it was found that the variations noted in the varieties *Rupsail* and *Patnai* were not significant, while in the variety *Latisail*, significant decrease in the number of ear-heads in some of the treatments was recorded.

TABLE 71

Variety	Rupsail				Latisail			Patnai		
Duration	24 hrs.	48 hrs.	72 hrs.	Mean	24 hrs.	48 hrs.	Mean	24 hrs.	72 hrs.	Mean
Treatment										
Control	12.7	11.7	11.4	11.9	20.7	17.0	18.8	12.2	11.9	12.0
10 μ c	13.8	10.1	9.4	13.1	10.4	16.0	17.7	14.2	13.8	14.0
100 μ c	14.0	15.0	13.3	14.1	15.6	17.4	16.5	11.9	15.6	13.8
1mc	12.1	14.1	12.9	13.0	18.3	20.0	19.2	14.2	12.7	13.4
Mean	13.2	14.2	11.8	13.0	18.5	17.6	18.0	13.1	13.5	13.3
Standard errors	Rupsail				Latisail			Patnai		
Body of the table	0.89				1.32			1.14		
Treatment	0.52				0.93			0.80		
Duration	0.45				0.66			0.57		

In the P³² treatments, as will be seen from Table 71, that in the varieties *Rupsail* and *Patnai*, some of the treatments had more ear-heads than their respective controls and these differences between the control and treatments were found to be statistically significant, while in the variety *Latisail*, no significant difference was seen when the treatments were compared against the control.

It has been mentioned earlier that all the three varieties were treated with different activities of P³² for 24, 48 and 72 hours. In the varieties *Latisail* and *Patnai* the ear-heads of the plants in the 72 hours and 48 hours durations respectively, could not be studied due to adverse circumstances. It may be seen from the same table that with increase in the duration of treatment, there was decrease in the mean number of ear-heads per plant, except in the variety *Patnai*, where the mean number of ear-heads in the 72 hours duration was found to be 13.5 as against 13.1 in the 24 hours duration. In the variety *Rupsail* only, significant differences were observed in the number of ear-heads in the different durations.

TABLE 72

Variety	Rupsail			Latisail			Patnai		
Duration	48 hrs.	96 hrs.	Mean	48 hrs.	96 hrs.	Mean	48 hrs.	96 hrs.	Mean
Treatment									
Control	11.1	9.3	10.2	12.3	9.8	11.0	11.9	8.7	10.3
50 μ c	6.1	7.5	6.8	13.5	11.3	12.4	9.9	8.0	9.0
500 μ c	11.6	9.4	10.5	13.2	7.6	10.4	11.4	8.8	10.1
Mean	9.6	8.7	9.2	13.0	9.6	11.3	11.1	8.5	9.8
Standard errors	Rupsail			Latisail			Patnai		
Body of the table	0.76			1.05			0.94		
Treatment	0.54			0.74			0.66		
Duration	0.44			0.61			0.54		

The S^{35} treatments in the first generation did not bring about any significant differences in the mean number of ear-heads, except in the variety *Rupsail*, where the plants treated with $50\mu c$ activity had very low number of ear-heads. Among the two durations of treatments i.e., 48 hours and 96 hours, the plants in the latter in the varieties *Latisail* and *Patnai* had lesser number of ear-heads and these differences were found to be statistically significant.

C.4.5.4. Yield of grains

In order to study the yield of grains per plant, records were taken from those ten plants from which the data for mean number of ear-heads per plant, were collected. The empty grains were removed and the weight of full grains in grammes were taken and statistical analysis on mean yield per plant in X_1 , P_1 and S_1 populations and their respective controls was made and tabulated in Tables 73, 74 and 75 respectively.

TABLE 73
 X_1 generation
MEAN YIELDS OF GRAINS (IN GMS) PER PLANT

Treatment	Variety		
	Rupsail	Latisail	Patnai
Control	32.8	50.5	43.1
5,000 r	30.2	32.7	52.2
10,000 r	31.8	30.2	43.2
20,000 r	30.6	28.1	42.8
40,000 r	21.6	25.8	46.5
S. E.	3.51	3.63	4.50

It will be seen from Table 73 that in the varieties *Rupsail* and *Latisail*, the X-irradiated plants yielded lesser quantity of grains than their controls. It may also be noted that in the variety *Latisail*, there is decrease in yield of grain with increase in dosage. In the variety *Patnai*, although some of the plants apparently yielded more grains than the control, these variations were not significant when analysed statistically.

TABLE 74
 P_1 generation
MEAN YIELDS OF GRAINS (IN GMS.) PER PLANT
Rupsail

Treatment	Duration			
	24 hrs.	48 hrs.	72 hrs.	Mean
Control	24.6	31.9	31.7	29.4
10 μc	32.9	41.7	26.0	33.5
100 μc	32.1	40.7	40.3	37.7
1mc	30.7	31.7	32.1	31.5
Mean	30.1	36.5	32.5	33.0

S. E. of the body of the table = 2.77
S. E. of the treatment = 1.60
S. E. of the duration = 1.39

TABLE 74 (Contd.)

Latisail

Treatment	Duration		
	24 hrs.	48 hrs.	Mean
Control	39.5	27.4	33.4
10 μ c	36.7	26.9	31.8
100 μ c	24.6	30.3	27.5
1mc	30.5	41.8	36.2
Mean	32.8	31.6	32.2

S. E. of the body of the table = 3.28
 S. E. of the treatment = 2.32
 S. E. of the duration = 1.64

Patnai

Treatment	Duration		
	24 hrs.	72 hrs.	Mean
Control	36.4	33.4	34.9
10 μ c	40.6	45.9	43.3
100 μ c	38.0	38.5	38.3
1mc	35.8	29.8	32.8
Mean	37.7	36.9	37.3

S. E. of the body of the table = 2.95
 S. E. of the treatment = 2.09
 S. E. of duration = 1.48

In the P_1 population, however, many of the treated plants yielded more grains than their controls. In the variety *Rupsail*, in the 48 hours duration, the 10 μ c and 100 μ c treated plants yielded more than their control. The former gave 41.7 gms. and the latter 40.7 gms., as against 31.9 gms. in the control. In the same variety, the mean yield of grain in the 48 hours duration was found to be 36.5 gms., and in 72 hours 32.5 gms., as against 30.1 gms., in 24 hours duration. All these differences mentioned above, were found to be statistically significant. In the variety *Latisail*, the 1 mc treatment for 48 hours was found to yield more (41.8 gms.) than the control (27.4 gms.) and other treatments. In the 72 hours duration, the 10 μ c treatment in the variety *Patnai* yielded 45.9 gms. as against 33.4 gms. in the control. These differences were found to be significant on statistical analysis.

From Table 75 it will be seen that in S_1 population, although the plants in some of the treatments appeared to have yielded more grains than their controls, the differences were not very marked. In general, with increase in the duration of treatment there is decrease in grain yield.

It may be mentioned here, that in most cases there exists a correlation between ear-heads and yields of grains.

TABLE 58 (Contd.)
MEAN TIME OF FLOWERING (IN DAYS) WITH S. E. FOR DIFFERENT VARIETIES

R-26					
Duration	4 hrs.	12 hrs.	24 hrs.	48 hrs.	Average
Treatment					
Control	126.6±0.89	137.5±0.79	129.2±1.07	145.8±0.97	133.1±0.49
2 μ c	120.7±0.87	134.2±0.77	130.2±0.88	143.6±0.67	130.1±0.43
20 μ c	121.1±0.62	134.2±1.37	126.8±0.88	142.0±1.04	129.2±0.48
200 μ c	122.6±1.49	135.3±0.84	127.8±1.25	144.0±1.32	132.2±0.59
2mc	123.8±2.05	135.6±0.72	129.0±1.43	141.8±1.14	134.5±0.55
Average	122.7±0.44	135.5±0.38	128.6±0.47	143.3±0.45	131.8±0.22

Chinsura Green					
Duration	4 hrs.	12 hrs.	24 hrs.	48 hrs.	Average
Treatment					
Control	*151.2±2.42	135.9±1.03	140.0±1.58	143.6±0.97	140.4±0.66
2 μ c	132.4±1.04	135.0±1.80	145.1±1.14	135.3±1.08	137.6±0.60
20 μ c	137.6±1.23	136.9±1.24	143.4±0.90	138.9±1.21	140.0±0.56
200 μ c	141.0±2.85	139.0±1.92	145.8±1.38	136.1±0.91	139.5±0.69
2mc	141.7±1.29	137.6±1.13	144.1±1.01	145.1±0.72	142.7±0.49
Average	137.5±0.65	136.8±0.58	143.7±0.52	140.0±0.43	140.2±0.26

* Average figure is based on 10 plants.

D-154					
Duration	4 hrs.	12 hrs.	24 hrs.	48 hrs.	Average
Treatment					
Control	127.8±1.00	125.8±0.80	124.9±0.67	122.1±0.67	125.3±0.41
2 μ c	126.6±0.78	128.3±0.94	123.0±0.66	120.8±0.74	125.1±0.42
20 μ c	124.8±0.64	126.3±0.88	121.1±0.87	121.1±0.99	124.1±0.42
200 μ c	125.2±0.71	125.2±0.91	120.8±1.15	123.1±0.58	124.2±0.42
2mc	126.6±0.66	124.9±1.44	122.8±1.13	122.1±0.80	124.7±0.46
Average	126.1±0.34	126.3±0.44	122.9±0.39	121.9±0.39	127.3±0.19

From Table 58, it will be seen that the variety D 154 is the earliest. It flowered earlier than T.M., C.G. and R-26 by 26, 13 and 5 days respectively.

In the variety T.M., the mean time of flowering for different treatments as well as for the control was practically the same, but significant differences were observed in the different durations of treatments. Compared to the first three durations, the flowering in the 48 hours duration was delayed by about 9—11 days but the differences among 4 hours, 12 hours and 24 hours treatments were not very marked.

A similar behaviour was also observed in the variety R-26 where the range of variation was only 4—5 days. When compared to the plants in the 4 hours duration, the plants

TABLE 75

S₁ generation

MEAN YIELDS OF GRAINS (IN GMS.) PER PLANT

Rupsail

Treatment \ Duration			
	48 hrs.	96 hr.	Mean
Control	30.1	10.4	20.2
50 μ c	13.2	12.8	13.0
500 μ c	28.2	14.0	21.1
Mean	23.8	12.4	18.1

S. E. of the body of the table = 2.00

S. E. of the treatment = 1.41

S. E. of the duration = 1.15

Latisail

Treatment \ Duration			
	48 hrs.	96 hrs.	Mean
Control	23.8	13.1	18.4
50 μ c	23.7	17.1	20.4
500 μ c	24.6	10.7	17.6
Mean	24.0	13.6	18.8

S. E. of the body of the table = 2.08

S. E. of the treatment = 1.47

S. E. of the duration = 1.20

Patnai

Treatment \ Duration			
	48 hrs.	96 hrs.	Mean
Control	35.3	28.3	31.8
50 μ c	25.5	15.7	20.6
500 μ c	42.8	23.4	33.1
Mean	34.5	22.4	28.5

S. E. of the body of the table = 3.07

S. E. of the treatment = 2.17

S. E. of the duration = 1.77

C.4.5.5. *Yield of Straw*

The data for the weight of straw were collected from the same ten plants from which the number of ear-heads and yields of grains were recorded. The mean yields of straw in grammes per plant of X₁, P₁ and S₁ populations and their respective controls are shown in Tables 76, 77 and 78 respectively.

TABLE 76

 X_1 generation

MEAN YIELDS OF STRAW (IN GMS) PER PLANT

Treatment \ Variety	Variety		
	Rupsail	Latisail	Patnai
Control	78.1	81.8	75.7
5,000 r	77.4	71.0	95.5
10,000 r	79.0	65.8	88.1
20,000 r	76.8	54.7	109.5
40,000 r	65.8	71.5	126.2
S. E.	6.68	5.92	8.78

It will be seen from Table 76 that only in variety *Patnai*, significant increase in yield of straw per plant was observed in the plants treated with 20,000 and 40,000 r X-rays.

TABLE 77

 P_1 generation

MEAN YIELDS OF STRAW (IN GMS) PER PLANT

Rupsail

Treatment \ Duration	Duration			
	24 hrs.	48 hrs.	72 hrs.	Mean
Control	66.4	69.2	62.0	65.2
10 μ c	86.8	79.7	54.7	73.0
100 μ c	74.5	70.7	61.7	68.3
1mc	63.0	73.6	68.4	67.6
Mean	72.7	73.3	61.7	69.2

S. E. of the body of the table = 5.11

S. E. of the treatment = 2.95

S. E. of the duration = 2.55

Latisail

Treatment \ Duration	Duration		
	24 hrs.	48 hrs.	Mean
Control	73.9	56.3	65.1
10 μ c	68.5	60.2	64.3
100 μ c	50.2	57.9	54.0
1mc	59.0	76.8	67.9
Mean	62.9	62.8	62.8

S. E. of the body of the table = 4.34

S. E. of the treatment = 3.07

S. E. of the duration = 2.17

TABLE 77 (Contd.)

Patnai			
Duration	24 hrs.	72 hrs.	Mean
Treatment			
Control	66.0	75.3	70.7
10 μ c	104.5	119.1	111.8
100 μ c	95.9	149.3	122.6
1mc	122.5	110.8	116.7
Mean	97.2	113.6	105.4
S. E. of the body of the table = 13.11			
S. E. of the treatment = 9.27			
S. E. of the duration = 6.56			

In the P_1 population, as seen from Table 77, in the variety *Rupsail*, the mean yield of straw in plants treated with 10 μ c activity was 86.8 gms. as against 66.4 gms. in the control. This difference and the variations observed between 24 hours and 72 hours duration have been found to be statistically significant. In the variety *Latisail*, the plants treated with 1 mc activity for 48 hours yielded 76.8 gms. of straw, as against 56.3 gms. in the control. No other significant differences were seen in this variety. In the variety *Patnai*, all the plants in the treated population, excepting those in 10 μ c and 100 μ c for 24 hours and 1 mc for 72 hours duration, yielded more straw than the controls. The differences were found to be again significant.

TABLE 78

 S_1 generation

MEAN YIELDS OF STRAW (IN GMS.) PER PLANT

Rupsail			
Duration	48 hrs.	96 hrs.	Mean
Treatment			
Control	43.7	26.7	35.2
50 μ c	24.5	24.5	24.5
500 μ c	36.4	34.7	35.6
Mean	34.8	28.6	31.7
S. E. of the body of the table = 2.78			
S. E. of the treatment = 1.96			
S. E. of the duration = 1.60			

TABLE 78 (Contd.)

Latisail			
Treatment	Duration		Mean
	48 hrs.	96 hrs.	
Control	30.0	23.3	26.7
50 μ c	32.8	29.9	31.3
500 μ c	37.9	27.6	32.8
Mean	33.6	26.9	30.3
S. E. of the body of the table = 2.24			
S. E. of the treatment = 1.58			
S. E. of the duration = 1.29			
Patnai			
Treatment	Duration		Mean
	48 hrs.	96 hrs.	
Control	48.2	49.7	48.9
50 μ c	35.9	44.4	40.1
500 μ c	44.2	55.6	49.9
Mean	42.7	49.8	46.3
S. E. of the body of the table = 4.24			
S. E. of the treatment = 3.00			
S. E. of the duration = 2.45			

G.4.5.6. *Heights of plants*

At the time of harvest, ten plants were selected at random from the X_1 , P_1 and S_1 populations and their respective controls in the three varieties of paddy studied and the heights attained by individual plants were measured. The mean heights of plants (in cms.) with standard error, are given in Tables 79, 80 and 81.

TABLE 79

Treatment	Variety		
	Rupsail	Latisail	Patnai
Control	196	161	186
5,000 r	198	164	190
10,000 r	200	162	190
20,000 r	183	158	196
40,000 r	191	156	202
S. E.	3.9	2.6	3.7

From Table 79 it will be seen that in the variety *Patnai*, the plants treated with 40,000 r X-rays were significantly taller than the control plants.

TABLE 80

Variety	Rupsail				Latisail			Patnai		
Duration	24 hrs.	48 hrs.	72 hrs.	Mean	24 hrs.	48 hrs.	Mean	24 hrs.	72 hrs.	Mean
Treatment										
Control	188	188	183	186	152	158	155	183	176	180
10 μ c	194	185	184	188	151	160	155	186	186	186
100 μ c	191	181	181	184	157	159	158	184	186	185
1 mc	192	182	184	186	159	158	158	189	182	185
Mean	191	184	183	186	155	159	157	186	182	184
Standard errors										
Body of the table				Rupsail 2.83			Latisail 1.91			Patnai 2.06
Treatment				1.64			1.35			1.46
Duration				1.42			0.96			1.03

From Table 80 it will be seen that the mean heights of plants in the three treatments viz., 10 μ c, 100 μ c and 1 mc in the variety *Patnai* were more than that of control plants. Significant increase in the mean heights of plants was observed in 1 mc treatment for 24 hours in the variety *Latisail* and 10 μ c and 100 μ c treatments for 72 hours in the variety *Patnai*. Among the two durations of treatments viz., 24 hours and 72 hours, the heights of plants in the latter were lesser than that of the former in the varieties *Rupsail* and *Patnai*, while in the variety *Latisail*, plants in the 48 hours duration were taller than those of 24 hours duration.

TABLE 81

Variety	Rupsail			Latisail			Patnai		
Duration	48 hrs.	96 hrs.	Mean	48 hrs.	96 hrs.	Mean	48 hrs.	96 hrs.	Mean
Treatment									
Control	145	128	137	122	112	117	139	141	140
50 μ c	138	126	132	107	123	115	131	127	129
500 μ c	129	124	126	122	121	121	136	141	139
Mean	137	126	132	117	119	118	136	136	136
Standard errors									
Body of the table				Rupsail 4.7		Latisail 2.0			Patnai 3.0
Treatment				3.3		1.4			2.2
Duration				2.7		1.2			1.8

In the S_1 population, as will be seen from Table 81, significant increase in the heights of plants were observed in the variety *Latisail* and in the treatments of 50 μ c and 500 μ c for 96 hours.

In the treated population, the plants which were found to be promising with regard to (i) yields of grains and straw, (ii) number of ear-heads, (iii) heights of plants, (iv) earliness in flowering and (v) non-lodging, (which is a very important economic character) have

been selected and the seeds collected from these plants will be grown in the X_2 , P_2 and S_2 generations in order to find out the behaviour of these characters in subsequent generations.

C.4.5.7. Cytological investigations

Cytological observations in the root tip cells and in the pollen mother cells are in progress. Meiotic abnormalities like non-disjunction, early separation of bivalents etc., have been observed in treated populations. A Critical study in the treatments with $50\mu\text{c}$ and $500\mu\text{c}$ activities of S^{35} for 96 hours revealed an increase in the frequency of chromosome aberrations with increase in activity of S^{35} .

C.4.5.8. Behaviour of the colour mutants in paddy in the S_2 generation

As reported earlier, during the 1955-56 season, two types of aberrant plants were isolated from the S^{35} treatments on the dry seeds of Patnai—a variety of *Oryza sativa*, which are as follows :

(i) In which the colour of the husk changed from yellow to red. The parent was awnless, while the aberrant plant had awns.

(ii) In which the seeds were smaller, but with awns, when the parent was awnless.

From the variety Bhasamanik, also of *O. sativa*, two aberrant plants were isolated in which the colour of the husk was dark brown as against yellow of the parent type.

These were grown during the year under report, in the S_2 generation, when it was found that the red husk coloured aberrant plant segregated into deep red and light red colour of the husk. The grains also were with or without awns. The colour of tillers were either green or red. Detailed inheritance studies are now being carried out.

The small seeded plant also segregated into small seeded and natural sized grains and with or without awns.

The plant with dark brown colour of the husk obtained in S_1 generation in the variety Bhasamanik bred true in S_2 generation.

Table 82 gives the statistical analysis of grain yield of the first two types i.e. the red husk type and the small seeded type.

TABLE 82
MEAN YIELD^{*} FOR 10 PLANTS (IN GMS), STANDARD ERROR (S.E.) AND
CRITICAL DIFFERENCES (C.D.)

Variety	Mean $\pm$ S.E.	C.D. at 5%	C.D. at 1%
Control	81.9 $\pm$ 7.58		
Red husk type	138.6 $\pm$ 7.58	23.78	38.78
Small seeded type	72.0 $\pm$ 7.58		

It will be seen from table 82 that the red husk type in general yielded more grains than the control; the latter also apparently giving a higher yield than the small seeded type. But the difference in yield between the control and the small seeded type was not statistically

significant. However, the increase in the grain yield of the red husk type over the control and the small seeded type was found to be significant at 1% level.

C.4.6. Preliminary studies on the effects of P^{32} and S^{35} in *Crotalaria*

During the year under report, preliminary experiments to study the effects of beta radiations in *Crotalaria juncea* L. (Sun-hemp) have been conducted. Seeds of a pure line were treated with S^{35} and P^{32} with initial activities at 570 μ c and 910 μ c respectively for 24 and 48 hours.

The plants arising from S^{35} treated seeds, did not show any important morphological differences, which the P^{32} treated plants did; such as deep scarlet colour on the dorsal surface of the standard petal as against golden yellow of the control. In others, three standard petals in a flower instead of the usual one, and two complete sets of petals, stamens and gynaecia enclosed in a single set of calyx were recorded. A study of the size and percentage of sterility of pollen grains has revealed remarkable variations. The diameter of the pollen grains varied from 10-26 μ in the treated as against 25-26 μ of the control. The highest average sterility was found to be 18.3% in case of P^{32} treatment for 48 hrs. as against 1.0% of the control. However, individual plants showed extremely high percentage of sterility in the treatments, the highest being 73.6% in one of the plants treated with P^{32} .

Studies on the meiotic abnormalities following treatments are in progress to determine howfar these abnormalities are responsible for pollen sterility.

In very few cases, bifurcation of the leaves and fasciation of the stem have also been recorded. Anatomical studies of these malformations are also in progress.

C. 5. Radiation Cytology

C.5.1. Study of physiological factors on induced mutagenesis in Paddy (*Oryza sativa* L.)

1. Effects of moisture on the mutagenic capacity of X-rays

Studies on the effects of radiations, especially with X-rays on both plants and animals started as early as 1927. Detailed investigations on the genetical and cytological changes induced by irradiations have been conducted by several workers since that time. These changes are mainly gene mutations, translocations, duplications and deficiencies following chromosome breakage. It is generally considered that these changes are due to the direct bombardment of the highly energetic electron. But it has been observed that all the cells exposed to uniform radiation do not respond in the same manner. This suggests the possibility of some physiological factors also, taking part in determining the resultant effect of X-rays. But the few available references in this connection reveal that very little work has been done on this line and hence it was considered necessary to conduct detailed investigations to find out the effects of physiological factors like moisture, temperature and various gases on the nature and degree of the mutagenic effects of these radiations.

The present work has been carried out to find the effects of moisture on the action of X-rays in *Oryza sativa* L. var. *Rupsail*. Seeds with various moisture contents were exposed to X-rays with the help of a "Philips Contact and Cavity Therapy" tube (50 KV and 2 mA.) without any filter, at a target distance of 12 cms.

The different doses used in each cases, were 1,000 r, 2,500 r, 5,000 r and 10,000 r, on seeds with the following moisture content.

- (1) Seeds desiccated for 90 hrs. (moisture content = 7.96%)
- (2) Seeds desiccated for 45 hrs. (moisture content = 10.37%)
- (3) Seeds at atmospheric humidity and temperature (moisture content = 11.38%)
- (4) Seeds soaked in water for 12 hrs. (moisture content = 19.36%)
- (5) Seeds soaked in water for 24 hrs. (moisture content = 26.28%)
- (6) Germinated seeds (moisture content = 32.2%)

In the case of the irradiated desiccated seeds, the percentage of germination was very low and the time taken was four days, while in the other cases the seeds germinated on the third day. There were a few cases of the suppression of the normal growth of the roots and a single case of polyembryony among the treated seeds. In the former case, the seedlings died after three days, while in the latter, it survived for a week.

Some seedlings were transplanted into pots. Weekly record of the growth of the plants was taken. During the first two weeks, there was no marked variation in the vegetative activity of the plants. But after two weeks, the growth was accelerated in 1,000 r and retarded in the case of 2,500 r, which lasted up to the seventh week. Then there was the gradual recovery in the case of 2,500 r so that at the time of flowering the plants attained similar heights in all the cases.

There were a few chlorophyll mutants in all the treated lots. They survived for a week after transplanting. There were a few plants having green leaves, which later turned yellow. These plants also died after five weeks.

Most of the cytological study was made from aceto-carmin squash preparations, mainly at anaphase and metaphase stages. The summary of all the anaphasic aberrations in relation to moisture content in the seeds is given in Table 83.

The chief aberrations noted were chromosome bridges, fragments, late separation of chromosomes etc. In the case of treated germinated seeds, heavy clumping of the chromosomes was also observed in addition to the above. This clumping was frequent during the first day after irradiation.

During the observations on the somatic cells, very few metaphase plates were seen in the case of desiccated seeds exposed to 2,500 r, in some of which the split chromosomes form loop like structures. A closer examination of the plates showed the failure of the separation of the chromatids at late metaphase, either at one end or at both the ends. The anaphasic repulsion between the two chromatids results in the pulling apart of the free regions, which is median in most of the cases. This gives rise to the ring shaped structure of the chromosomes. There can be three possible explanations for the occurrence of such a phenomenon.

TABLE 83

Nature of seed and % of water content	DOSAGE											
	1,000 r			2,500 r			5,000 r			10,000 r		
	No. of cells exa- mined	No. of aber- rent cells	% aber- rat- ions	No. of cells exa- mined	No. of aber- rent cells	% aber- ration	No. of cells exa- mined	No. of aber- rent cells	% aber- ration	No. of cells exa- mined	No. of aber- rent cells	% aber- ration
Desiccated for 90 hrs. (7.962%)	—	—	—	11	1	9.1	76	2	2.63	32	2	6.2
Desiccated for 95 hrs. (10.37%)	—	—	—	—	—	—	23	1	4.3	76	5	6.58
Ordinary seed (11.88%)	83	11	13.25	362	24	6.63	487	40	8.213	132	16	12.12
Soaked in water for 12 hrs. (19.96%)	151	6	3.907	129	5	3.87	35	2	5.71	50	4	8.0
Soaked in water for 24 hrs. (26.288%)	132	4	3.03	194	7	3.60	167	5	2.99	208	4	1.92

Firstly, it may be caused by the stickiness of the chromosome ends due to irradiation, which is more of a pathological condition, or it may be due to the segmental interchange of the ends, leading to the formation of the contact between the tips, forming "pseudochiasmata". Another possible explanation is that the normal cycle of the division of the chromatids and the kinetochore has been disturbed due to the action of X-rays. There exist four definite regions within a chromosome with distinct division cycle. They are in order of the occurrence.

- (1) median
- (2) chromosome ends
- (3) kinetochore
- (4) most proximal region of the arms.

In the normal course of separation, after the first two stages of divisions are over, the chromosomes assume X-shaped figure. But due to the effect of X-irradiation, this sequence of division is upset, and the separation of the ends (i.e. the second region within the chromosome) is accomplished last, giving rise to the ring shaped condition.

The aberrations were more in the case of the desiccated and germinated treated seeds. But when the seeds were soaked and treated, the aberrations were less. It was concluded that the radiation induced disturbances in the chromosomes decrease with increased moisture content within a range of 7% to 26% with a sensitivity increase at lower as well as higher moisture contents. This was more pronounced in the higher doses.

For temporary preparations, flower buds were smeared in iron aceto-carmine. The materials were also fixed in Navashin A and B (1 : 1) after prefixing in Carnoy's fluid and permanent preparations were made following the usual schedules and staining with crystal violet.

A detailed study of the various meiotic aberrations is in progress. The percentage of aberrations vary with different doses. In few cases, univalents were found lying outside the spindle which may be lost or form separate micro-nuclei. On further examination, some pollen mother cells were observed showing the presence of micro-nucleus. The abnormal features noted were the occurrence of laggards and unequal distribution of the chromosomes at anaphase and in some cases interbivalent connections at metaphase. In a number of cases, less than the normal number of bivalents were seen, the number varying from seven to eleven. This may be due to some mis-division in the previous division or in the premeiotic mitosis.

Detailed investigations on the effects of X-rays on pollen grains have been conducted. There was marked variation in the percentage of pollen sterility between the treated plants and the control. In the control, the percentage sterility was only 2.07, while in 1,000 r it was 9.4, in 2,500 r it was 6.08, and in 5,000 r it was 11.07. As regards the size of the pollen grains, in the control they were almost of uniform size, (about 35.8 μ in diameter), while in the treatments there was great variation in size including small pollen grains measuring 24.0 μ as well as large grains measuring 60.0 μ .

2. Radio-active Sulphur

Experiments were also conducted with radio-active Sulphur (S^{35}) to find out how far the moisture affects its mutagenic properties.

Spring variety of *O. sativa* var. *Boro* was selected for this study. Seeds with various moisture contents were treated with S^{35} having initial activities of 259.0 μ c and 519.78 μ c for 24 and 48 hrs. The following were the condition of the seeds at the time of treatment.

- (1) Seeds desiccated for 96 hrs.
- (2) Seeds desiccated for 48 hrs.
- (3) Seeds at atmospheric humidity and temperature
- (4) Germinated seeds.

In each of the above cases, the moisture content of the seed at the time of treatment was determined and the atmospheric humidity and temperature noted.

The treated seeds were allowed to germinate on moist filter papers in petri-dishes. The treatments did not seem to have any appreciable effect on the percentage and rate of germination of the seeds.

The treatments however, affected the mitotic activity considerably. The main abnormalities observed were bridges, fragments, laggards, micronuclei etc. There were cases of metaphase plates showing split chromosomes forming loop like structures. This type of abnormality was seen even in the anaphase cells.

A statistical analysis of the percentage of abnormalities in mitosis and meiosis, percentage sterility and variation in the size of the pollen grains in the treated progenies is in progress.

C. Cytology (ii)

C.6.1. Cytogenetics and Cytotaxonomy of Leguminosae

1. Species and varieties under investigation

Cytological investigations in Indian species of *Crotalaria* were continued during the year under report, in an attempt to study the nature of speciation and evolution within the genus. In all, fourteen species viz. *C. albida*, *C. anagyroides*, *C. fulva*, *C. grahamiana*, *C. juncea*, *C. laburnifolia*, *C. medicaginea*, *C. orixensis*, *C. pulcherrima*, *C. retusa*, *C. saltiana*, *C. sericea*, *C. usaramoensis* and *C. verrucosa* have been investigated mitotically, while meiosis has been studied in only five of them, namely, *C. grahamiana*, *C. juncea*, *C. saltiana*, *C. sericea* and *C. verrucosa*.

A remarkable constancy of the somatic chromosome number ($=16$) has been found to exist in all the species except *C. verrucosa* var. Ceylon, where the somatic number has been found to be $17(2n+1)$. In the absence of polyploidy in the genus, evidences were sought in the morphology of the somatic chromosomes which have been analysed with the help of idiograms on the basis of the ratio between the median and sub-median position of the centromere, total length of the complement and the size of the duplicated pair of chromosome, which occurs as a regular feature in all the species examined. Interpretations of the variations in these aspects, have helped to arrive at a tentative scheme of evolution within the genus, according to which the section *Simplicifoliae*, which is characterized by the unifoliate forms is most primitive, while the section of *Multifoliolatae* with 5-7 leaflets is the most advanced. The *Trifoliatae* seem to occupy the middle position. This fact is further confirmed by the habit of the plants in the three sections; where the *Multifoliolatae* are composed entirely of annual herbs, the other two sections include both the herbs and the shrubs, some of which showed a tendency to become perennial under favourable conditions.

The study of meiosis has yielded valuable information on the constitution of species as well as their stability. In certain species, particularly in *C. saltiana* and *C. sericea*, a large number of meiotic abnormalities like presence of univalents, anaphase bridges, laggards, extrusion, unequal distributions, cytotoxicity etc. have been recorded.

Besides, the phenomena of polyembryony, presence of centromeric granules and a variable number of chromomeres in the SAT-stalk have also been recorded. Further studies on the last viz. the structure of the SAT-stalk has opened an interesting line of research and further work in this connection is in progress.

2. *Aeschynomene*, *Butea* and *Clitoria*

Cytogenetical investigations have also been undertaken during the year in the above genera of Leguminosae, viz: *Aeschynomene*, *Butea* and *Clitoria*.

The mitosis of the following species has been thoroughly worked out :

1. <i>Ae. americana</i>	$2n = 20,$	$n = 10$
2. <i>Ae. indica</i>	$2n = 40,$	$n = 20$
3. <i>Ae. aspera</i>	$2n = 36,$	$n = 18$
4. <i>Butea frondosa</i>	$2n = 18,$	

5. <i>Clitoria ternatea</i> (Blue flowered)	$2n = 16,$	$n = 8$
6. <i>Clitoria ternates</i> (white flowered)	$2n = 16,$	$n = 8$
7. <i>C. cajanifolia</i>	$2n = 24$	

Thus, it was found that at least in *Aeschynomene* and *Clitoria*, there exists a high degree of polyploidy which either partly or wholly has been responsible for speciation in these genera. The nature of polyploidy has been investigated by the meiotic behaviour of these species and confirmed by the evidences of morphology of somatic chromosomes. It has been concluded from this study that *Ae. americana* is a secondarily balanced pentaploid, while *Ae. indica* is a decaploid evolved from the former. *Ae. aspera*, however, appears to be a secondarily balanced nonaploid of an allopolyploid origin. Similarly *C. ternatea* has been found to be a tetraploid whereas *C. cajanifolia* is a hexaploid of a hybrid origin involving two or more different species in the course of its evolution.

The meiotic studies in these species have also yielded interesting abnormalities. Besides, a pronounced tendency of secondary association of the bivalents at metaphase I in species of *Aeschynomene* has been recorded. The most frequent association in all the three species investigated is in four groups. This phenomenon and a critical study of the nucleolar chromosomes and nucleoli have confirmed the earlier suggestion that 4 is the basic chromosome number in *Leguminosae*.

III. Effect of Auxins

A comparative study of the effects of various auxins on growth and cytology was also undertaken during the year under report. Pollen tube was selected as the medium for such experimentation due chiefly to the rapid rate of growth of the tubes as well favourable response of *Crotalaria jucea*. L. pollen grains to the culture conditions. The following substances were tried :—

1. Sodium salt of 2, 4-Dichlorophenoxy acetic acid (2, 4-D)
2. 2, 4, 5-Trichlorophenoxy acetic acid (2, 4-5T)
3. 2, methyl, 4-chlorophenoxy acetic acid (M.C.P.A.)
4. Sodium trichloro acetate (Na-T.C.A.)
5. Indole acetic acid (I.A.A.)
6. Indole propionic acid (I.P.A.)

Pollen grains were germinated on Conger's agar-agar medium containing lactose and uniform conditions of temperature and moisture were maintained. The auxins were applied in equal quantities in 100, 500, 1,000, 2,500 and 5,000 p.p.m. concentrations in every case.

The growth response of pollen tubes in case of each treatment was studied by taking an average of the tube lengths 1, 2, 4, 6, 8, and 24 hours after sowing. It has been found that there is maximum effect in I.A.A. followed by 2, 4-5T and 2, 4-D. The greatest

tube length was reached in case of grains treated with T.C.A., but it did not exhibit any hormonal properties.

Besides the growth, a large number of morphological abnormalities are induced as a result of the auxin treatment like vacuolation and granulation of the cytoplasm, swelling of the tips of pollen tubes, bursting of the tubes and the grains, lamellation and bifurcation and branching of the tubes. In some cases two tubes have also been recorded arising out of a single grain. These phenomena are interesting from the view point of nature, degree and mode of action of auxins on rapidly growing plant cells.

The tube mitosis has been thoroughly investigated in the material and good preparation in Feulgen's stain, showing even the morphology of the chromosomes in the tubes have been obtained. The effects of various auxins on the mitosis were also studied. Within the range of concentrations of treatments permitting germination of grains, there was a pronounced delaying of mitosis. In certain cases, particularly in case of T.C.A., the treatment adversely affected the nucleic acid content of the chromosomes, resulting in their poor response to leuco-basic fuchsin reaction. However in no case, a complete disintegration of the nuclei was observed. In case of the 2, 4-D treated tubes, there was very heavy clumping of the chromosomes.

Besides these, an interesting observation was made on the presence of an yellow oily substance termed "Pollenin" on the surface of *Crotalaria* pollen grains. This substance is liberated on the culture medium when the grains are sown and appears to have some kind of growth influencing properties.

C.6.2. Investigations on the sex-chromosomes in plants

The available literature on this topic is scanty and the results are conflicting and hence it was considered desirable to reinvestigate as many of the genera as available, in which sex-chromosomes have been reported.

Coccinia indica, a member of the family Cucurbitaceae has been reported to have distinct sex-chromosomes. In the re-investigation of this species, improved fixatives and techniques have been used to bring out the morphology of the chromosomes, so as to distinguish the autosomes from the sex-chromosomes. Excellent temporary preparations of the somatic tissues have been obtained by using Aesculin as a pre-fixative at 10°C for 4 hours, followed by fixation in acetic-alcohol. By this method, the long Y chromosome with median primary constriction as well as the autosomes bearing distinct constrictions, could be made out clearly. The root tips were treated with trichloroacetic acid, to find out the chemical nature of the Y chromosome. The results of preliminary investigations indicate that the Y chromosome, which is supposed to be heterochromatic, reacts differently from the heterochromatic portions of the autosomes. X-ray irradiation with low doses followed by acetic-alcohol fixation, were attempted to see the behaviour of the irradiated sex-chromosomes, especially the Y or the long chromosome in the male complement. However, the fixations were not satisfactory and therefore it is proposed to try other improved fixations for such purposes. Colchicine treatment, followed by intercrossing, to get inter-sexes

among the polypliod progenies will be attempted. These inter-sexes, if obtained, is expected to throw more light on the functions of the X and Y chromosomes.

A few other plants in which sex-chromosomes have been reported by earlier investigators are also being investigated, but in these, the presence of sex-chromosomes have not so far been detected. They are :—

(1) *Trichosanthes dioica*, belonging to the family Cucurbitaceae, where the somatic number in both male and female plants is 22. In this, a large number of chromosomes were observed having secondary constrictions, in both the male and female complements, but the heteromorphic pair could not be distinguished. Oxyquinoline was added to the chromic-formalin fixative when, it gave better results.

Hydrilla verticillata (Family-Hydrocharitaceae). The $2n$ number was found to be 24, but the presence of sex-chromosomes could not be confirmed. The fixative used was a saturated solution of Aesculin, for 15 minutes at 10 C.

(3) *Putranjiba Roxburghii* (Family-Euphorbiaceae). Great difficulty was experienced in germinating the seeds and hence the $2n$ number was determined from leaf tip smears, which was found to be 14, sex-chromosomes could not be identified.

(4) Investigations on other species like *Trewia nudiflora* (Family-Euphorbiaceae) *Trichosanthes palmata* (Family-Cucurbitaceae) and *Cannabis sativa* (Family-Cannabinaceae), in which sex-chromosomes have been reported by earlier workers, are also in progress.

C. 7. Anatomical studies

C.7.1. Jute

The earlier anatomical studies with regard to the number of ultimate fibre cells in the Tall Mutant and R-26, the former X-ray mutant and the latter its control, belonging to *Corchorus olitorius* L. revealed 50 percent more fibre cells in the former. But these observations were however restricted to the transverse sections from the basal region of stems only i.e., one inch above soil level. During the period under report, more comprehensive observations and counts of ultimate fibre cells were made from three regions of a plant viz. (i) basal—1" above soil level (ii) middle and (iii) top—2" below apical bud.

Ten plants of each variety were collected at random during the harvest time and transverse sections were cut from three regions of each plant, as stated above and stained in safranin and mounted in glycerine for bringing out the structure of the fibre.

In the transverse sections of stem at the basal regions of the two varieties, the phloem bundles appear somewhat conical in shape; they are broad at the base lying next to cambium ring and gradually tapering towards the top near the cortex. They are arranged like the spokes of a wheel round the xylem and are separated from each other by medullary rays of varying width. Each of these phloem bundles consists of alternate arcs of thick walled fibre patches and thin walled tissues arranged concentrically. Again, the fibre patches in each arc alternate laterally with thin walled

phloem rays. The outermost fibre patch or patches forming a cap like structure over the entire phloem bundle belong to the primary phloem and all other internal tissues of phloem, both thin or thick walled, are derived from the cambium ring formed during secondary growth. The fibre arcs of each phloem bundle consist of varying number of fibre patches which are separated laterally from each other by uniseriate or biseriate cells of phloem ray. These ray cells are thin walled and appear quadrangular or radially elongated in transverse sections. Some of them may also appear spindle shaped and multiseriate at least in the swollen middle part of a few phloem bundles. The soft bast lying between any two adjacent fibre patches on the same radius is composed of the usual tissues of sieve tubes, companion cells and phloem parenchyma. The patches of soft bast appear mostly rectangular, the individual cells of which are usually flattened after secondary growth. It is therefore, seen clearly that each of these fibre patches is surrounded on all sides by thin walled tissues. The number of fibre patches is maximum near about the base and minimum at the top in a phloem bundle. The oldest fibre patches are situated towards the periphery and the younger ones are successively inwards; the youngest lying next to the cambium ring. The shape and size of the fibre patches are very variable. They may be square, rectangular or even radially elongated. The last type is more often seen in the outer arcs or the margins of the phloem bundles.

It is interesting to note in this connection that in transverse sections, the phloem bundles in the basal, middle and top regions of a stem appear conical, truncated and somewhat corrugated respectively.

The average number of ultimate fibre cells for the two varieties at the three regions are shown in Table 84.

TABLE 84
AVERAGE NUMBER OF ULTIMATE FIBRE CELLS (IN THOUSANDS) FOR TWO
VARIETIES OF JUTE AT THE THREE REGIONS OF BASE, MIDDLE AND TOP

	T.M.	R-26	Difference $\pm$ S. E.	t-test	Ratio of two averages
Base	54.60	36.05	18.55 ± 8.52	2.171* d.f. = 18	1.51
Middle	33.93	22.12	11.81 ± 4.83	2.445* d.f. = 18	1.53
Top	3.32	2.26	1.06 ± 0.37	2.865* d.f. = 18	1.47

* denotes significance at 5% level.

From the above table it may be observed that the average number of ultimate fibre cells in T.M. is significantly higher than that of R-26 at the three regions. It may further be noted that ratio of the average number of ultimate fibre cells of T.M. to that of R-26 maintains almost equal order of 1.5 at the three regions. It is also observed that the maximum number of ultimate fibre cells are found at the base, lesser in the middle and least in the top, of each variety.

C.7.2. *Abnormal ascidia and "paired leaves" in Ageratum conyzoides L.*

Ageratum conyzoides is an erect and hairy annual weed, the leaves of which are petiolate having opposite decussate phyllotaxy.

Some of these plants bear stalked ascidium (cup) which is somewhat similar to the cup of *Clerodendron infortunatum* Gaertn, reported earlier (Curr. Sci., 20, 48-49, 1951). The stalked cup of *Ageratum* here studied, is terminal to the main axis and composed of the terminal pair of leaves which are united laterally along both the adjacent margins of the petioles and leaf-blades. Ascidia of various shapes and sizes have been noted. Each of the cup has two opposite leaf tips and the length of its stalk is nearly equal to that of a normal petiole. The basal part of the ascidial stalk is wider and hollow within engulfing the terminal bud, which may grow up into a leafy shoot later through a slit. Morphologically and anatomically the ascidial stalk is petiolar in origin and the cup itself reveals that the inner and outer surfaces of the same correspond respectively to the ventral and dorsal surfaces of the normal lamina.

Sometimes, the two opposite leaves of the same node become abnormally united along the two adjacent margins on one side only, the other two margins remaining quite free and thus gives rise to "paired leaves". In some cases, the fusion of the two leaves may be confined to the petioles only, the lamina remaining quite free while in others it extends upwards to the lamina also.

Further anatomical studies are in progress. It may be mentioned here, that such features are often observed in irradiated populations of many plants, when their controls do not show any variations.

C.7.3. *Cyperus rotundus L*

During the course of anatomical investigations, a new type of transition of the vascular bundles from the concentric to collateral form was observed in *Cyperus rotundus* which takes place just below the point of attachment of the inflorescence axis to the underground stem, a short note on which has been published.

Further investigations in these lines are in progress.

C.7.4. *Croton sparsiflorus Morung*

During the year under report the anatomical and morphological responses of *Croton sparsiflorus*, a common weed, to the application of 2, 4-dichlorophenoxyacetic acid at 1000 p.p.m. in 0.5% Carbowax 1500 were investigated.

(i) *Spray application*—The pronounced effects on the roots were, the formation of root tip enlargement mainly due to the lateral growth of the inner cortical cells and production of wing like out-growths on the main root as a result of the failure of root primordia to separate, which after a period of growth have lost their meristematic activity. Formation of root primordia in the enlarged portion of the root tip was also a common phenomenon.

Though there was not much of anatomical change in the stem of many, plants a few showed proliferation along the first internode at the top which was due to the proliferation of the cortex, pith and formation of secondary tissues by cambium rings formed round the internal phloem strands in addition to the activity of the normal cambium.

A few petioles proliferated when attached to the plant. It was due to the proliferations of the ground tissue and formation of secondary vascular elements by the activity of cambium formed all round the xylem of each bundle. A few instances of the formation of cambium ring, connecting most of the vascular bundles were also observed. The occurrence of somewhat similar nature of proliferation in the stem and petiole provides an additional evidence to the partial shoot theory of leaf elaborated by Arber.

(ii) *Application at the cut Surface of decapitated stems.* The treated stems enlarged at the cut region forming a tumor and anatomical observations were made at regular intervals. Among the general features of response observed are (a) high degree of response of pith and cortical cells, (b) frequent differentiation of reticulate tracheids in the maturation of proliferated tissue (c) secondary xylem differentiated after treatment composed of tracheids but no vessels (d) formation of secondary vascular elements by the activity of the cambium rings formed round the internal phloem strands (e) infrequent occurrence of root primordia and (f) formation of cork tissue over the tumor.

C. 8. Weed Control

C.8.1. Control of weeds by the use of hormone type of selective weed killers

This is a co-ordinated scheme financed by the Indian Council of Agricultural Research and is in the fourth year of investigation, during the year under report.

The weeds selected for detailed studies are (1) *Cyperus rotundus* L., (2) *Vicia sativa* L., (3) *Imperata arundinacea* Cyrill., (4) *Ludwigia parviflora* Roxb., (5) *Rottboellia compressa* L., and (6) *Eichornia crassipes* Solms.

The chemicals included in the trails were the same as for the previous year and are 2, 4-D, Cornox D, Dicotox, Fernoxone, Crag Herbicide I, 2, 4, 5-T, M.C.P.A., Cornox M, Agroxone, Na-T.C.A. In addition preliminary experiments were conducted with certain other proprietary, weedicides such as 'Weedazol' (Na-Aminotriazole), 'Geigy Weed-killer' (Aminotriazine) and 'Tropotox' (M.C.P. butyric acid).

The experiments with the last three chemicals were conducted on weeds grown in pots and effects in relation to the concentrations applied and the time taken for killing of the weeds have been studied on three of the specified weeds only viz :—

1. *Cyperus rotundus* L.
2. *Eichornia crassipes* Solms
3. *Imperata arundinacea* Cyrill.

The data obtained from these trials is incorporated in Table 85.

TABLE 85

Name of the chemical	Cyperus rotundus		Eichornia crassipes		Imperata arundinacea	
	Concentration of chemical	Days required for killing	Concentration of chemical	Days required for killing	Concentration of chemical	Days required for killing
1. Weedazol (Na-Aminotriazole)	2,500 p.p.m.	11	2,500 p.p.m.	6*	2,500 p.p.m.	—
	5,000 p.p.m.	12	5,000 p.p.m.	7*	5,000 p.p.m.	15*
	10,000 p.p.m.	—	10,000 p.p.m.	7*	10,000 p.p.m.	14*
2. Geigy weed killer (aminotriazine)	2,500 p.p.m.	no effect	2,500 p.p.m.	7	2,500 p.p.m.	—
	5,000 p.p.m.	15*	5,000 p.p.m.	7	5,000 p.p.m.	—
	10,000 p.p.m.	14*	10,000 p.p.m.	5	10,000 p.p.m.	—
3. Tropolox (M. C. P. Butyric acid)	5,000 p.p.m.	16	2,500 p.p.m.	18	5,000 p.p.m.	—
	10,000 p.p.m.	16	5,000 p.p.m.	11	10,000 p.p.m.	—
	20,000 p.p.m.	15	10,000 p.p.m.	8	20,000 p.p.m.	—

* Did not bring about complete killing and occasional revival was noticed.

From these investigations it appears that although all the three chemicals are toxic to the weeds mentioned above, 'Weedazol' and 'Geigy Weed-killer' are non-selective whereas 'Tropolox' is a hormone type of selective herbicide.

Most of the field experiments were conducted at the Experimental Stations of the Bose Institute at Shyamnagar and at Falta. Some were also carried out in fallow lands, in and around Calcutta. The experiments in the pots were conducted at the Bose Institute, Calcutta.

ITEM 1. The most effective time of application—morning, evening, sunny, cloudy and rainy etc.

Herbicidal and sub-lethal concentrations of 2, 4 Dichlorophenoxy acetic acid and 2, Methyl 4-Chlorophenoxy acetic acid formulations were sprayed on the selected weeds, viz :—*Eichornia crassipes*, *Rottboellia compressa*, *Ludwigia parviflora*, *Cyperus rotundus*, *Imperata arundinacea* and *Vicia sativa*,—separately in the mornings and evenings on rainy, sunny and cloudy days. Invariably, all the herbicidal chemicals used showed greater lethal or injurious action when sprayed in the morning than when sprayed in the evening in that they usually died or showed severe injury earlier. Heat and bright light seem to cause an enhancement of the herbicidal action in the plants sprayed in the morning. Sprays applied during or just before rains, showed considerable diminution in the activity. A minimum period of 6-8 hours during which the sprays stick on to the leaves has been found necessary for proper herbicidal penetration and subsequent toxic action. However, where the chemicals washed off by rain were allowed to accumulate in the pot as in the case of *Eichornia crassipes*, there was not so much diminution in activity. Reduction in phytotoxic activity by rain fall was more pronounced in the case of amine and sodium salt formulations, than in the ester formulation. As far as sunny and cloudy days are concerned, there was dif-

ference in number of days required for complete killing. However, the initial action was more apparent in sunny day than in cloudy days. The results are contained in Table 86, 87, 89, 90, 91 and 92.

The effects of the herbicides on *Vicia sativa* could not be studied in summer conditions due to its non-availability.

TABLE 86

Name of weeds	Concentration of Fernoxone* applied	No. of days required for complete killing				
		Time of spraying				
		Morning	Evening	During rains	Cloudy days	Summer days
1. <i>Eichornia crassipes</i>	0.7%	15	15	30	18	12
2. <i>Ludwigia parviflora</i>	0.7%	15	15	25	18	—
3. <i>Rottboelia compressa</i>	7.0%	30	30	45	40	—
4. <i>Vicia sativa</i>	1.5%	5	5	—	7	—
5. <i>Cyperus rotundus</i>	6.0%	7	7	20	15	8
6. <i>Imperata arundinacea</i>	8.0%	20	20	35	30	15

* Na-Salt of 2,4-D (80%).

TABLE 87

Name of the weeds	Concentration of Cornox D* applied	No. of days required for complete killing				
		Time of spraying				
		Morning	Evening	During rains	Cloudy days	Summer days
1. <i>Eichornia crassipes</i>	1.0%	15	15	20	18	10
2. <i>Ludwigia parviflora</i>	2.0%	12	12	20	15	—
3. <i>Rottboelia compressa</i>	15.0%	28	28	40	40	25
4. <i>Vicia sativa</i>	0.5%	5	5	—	8	—
5. <i>Cyperus rotundus</i>	5.0%	15	15	25	20	12
6. <i>Imperata arundinacea</i>	12.0%	25	25	40	32	20

* Amine Salt of 2,4-D (32.0%).

TABLE 88

Name of weeds	Concentration of Dictox* applied	No. of days required for complete killing				
		Time of spraying				
		Morning	Evening	During rains	Cloudy days	Summer days
1. <i>Eichornia crassipes</i>	1.0%	15	15	35	28	14
2. <i>Ludwigia parviflora</i>	2.5%	15	15	25	20	13
3. <i>Rottboelia compressa</i>	15.0%	30	30	40	32	20
4. <i>Vicia sativa</i>	1.25%	4	4	10	7	6
5. <i>Cyperus rotundus</i>	7.0%	15	15	32	20	14
6. <i>Imperata arundinacea</i>	15.0%	35	35	48	40	35

* Butyl ester of 2,4-D (10%).

TABLE 89

Name of weeds	Concentration of Crag Herbicide-I* applied	No. of days required for complete killing				
		Time of spraying				
		Morning	Evening	During rains	Cloudy days	Summer days
1. Eichornia crassipes	—	—	—	—	—	—
2. Ludwigia parviflora	0.5%	20	20	30	25	15
3. Rottboelia compressa	—	—	—	—	—	—
4. Vicia sativa	1.0%	3	3	8	5	3
5. Cyperus rotundus	5.0%	8	8	15	10	7
6. Imperata arundinacea	—	—	—	—	—	—

* Sodium 2,4-Dichlorophenoxy ethyl sulphate.

TABLE 90

Name of weeds	Concentration of 2,4,5-T* applied	No. of days required for complete killing				
		Time of spraying				
		Morning	Evening	During rains	Cloudy days	Summer days
1. Eichornia crassipes	0.75%	15	15	28	22	12
2. Ludwigia parviflora	1.0%	15	15	30	24	—
3. Rottboelia compressa	10.0%	28	28	38	30	28
4. Vicia sativa	1.0%	5	5	10	8	—
5. Cyperus rotundus	7.0%	20	20	35	30	20
6. Imperata arundinacea	10.0%	22	22	45	40	22

* 2,4,5 Trichlorophenoxy acetic acid.

TABLE 91

Name of weeds	Concentration of Agroxone 3* applied	No. of days required for complete killing				
		Time of spraying				
		Morning	Evening	During rains	Cloudy days	Summer days
1. Eichornia crassipes	0.75%	13	13	22	18	10
2. Ludwigia parviflora	1.5%	15	15	32	25	15
3. Rottboelia compressa	12.0%	30	30	50	42	30
4. Vicia sativa	0.75%	6	6	11	9	—
5. Cyperus rotundus	4.0%	12	12	20	18	12
6. Imperata arundinacea	9.0%	15	15	32	28	14

* 2-Methyl, 4-Chlorophenoxy acetic acid.

TABLE 92

Name of weeds	Concentration of Na-T.C.A.* applied	No. of days required for complete killing				
		Time of spraying				
		Morning	Evening	During rain	Cloudy days	Summer days
1. <i>Eichornia crassipes</i>	3.5%	14	14	25	20	12
2. <i>Ludwigia parviflora</i>	3.0%	14	14	28	22	14
3. <i>Rottboelia compressa</i>	7.5%	30	30	45	38	30
4. <i>Vicia sativa</i>	2.0%	10	10	28	25	—
5. <i>Cyperus rotundus</i>	5.0%	12	12	25	10	10
6. <i>Imperata arundinacea</i>	7.5%	20	20	38	30	22

* Sodium Salt of Trichlorophenoxy acetic acid.

N.B.—The concentrations of the various chemicals used for all the weeds are the optimum reported during the previous year.

ITEM 2. *Physiology of different weeds and crops in relations to their reaction to different weed-icides.*

(a) The most effective stage for the weeds for the application of weedicides and the least harmful stage for the crops, such as pre-showing, seedling, pre-flowering, pre-harvest and harvest.

The sodium salt, amine and ester formulations of 2, 4, D, and M.C.P.A. have been found to be more or less effective at every stage of the growth of weeds. But in the case of narrow leaved weeds such as *Imperata*, *Rottboelia* etc. the seedling stage was more susceptible than the mature stage. The data has been included in Table 93.

TABLE 93

Name of the Herbicide	WEEDS Stage when it is most harmful						CROPS Stage when least harmful			
	<i>Cyperus rotundus</i>	<i>Eichornia crassipes</i>	<i>Ludwigia parviflora</i>	<i>Vicia sativa</i>	<i>Imperata arundinacea</i>	<i>Rottboelia compressa</i>	Jute	Paddy	Sugarcane	Mustard
Cornox M	early	all	early	all	early	early	harvesting	Pre-flowering	Pre-flowering	harvesting
Cornox D	"	"	"	"	"	"	"	"	"	"
Fernoxone	"	"	"	"	"	"	"	"	"	"
Agroxone	"	"	"	"	"	"	"	"	"	"
Dicotox	"	"	"	"	"	"	"	"	"	"
2,4-5 T	"	"	"	"	"	"	"	"	"	"
Crag Herbicide I	Germi-nating	Germi-nating	Germi-nating	all	nil	nil	all stages except seedling	all stages except seedling	all	Flowering
Na-T.C.A.	early	early	early	early	early	early	Pre-Flowering	harvesting	harvesting	harvesting

The least harmful stage for the crops has been investigated by spray applications of the weedicides at pre-sowing, seedling, pre-flowering, flowering, pre-harvest and harvest times. Pre-sowing application when carefully done taking into consideration the retention of toxicity of the sprayed herbicides, was least harmful to the crop. On the other hand application of the herbicides during seedling stage showed the most injurious effect on the crop plant. Application of the herbicides at pre-flowering and flowering stages had shown less deleterious and lasting effect on the crop. Pre-harvest and harvest stage applications were not of any advantage.

(b) Study of the penetrating powers of the spray-dust and the ability of the plant to absorb and transport growth regulating chemicals.

Spray applications of all the formulations were made with low and high volume-spraying equipments. Dust application with a rotary duster, was made in the case of Fernoxone. In all cases spray applications were found to be more effective than dust. Dust application consumed a much greater quantity of the chemical per unit area to bring about the desired herbicidal effect. Drift hazards were more prominent in dust application. Dust gave smaller spreading and less sticking and coverage on the foliage, resulting in slower penetration of the chemical into the internal tissues through the cuticle. The greater stickiness of sprays than of the dusts, was noticeable clearly in the case of glabrous leaved weeds. However, the siliceous and hairy out-growths present in certain plants helped in retaining part of the dust among them and thereby caused effective penetration in course of time, while plants having no such out-growth allowed the dust particles to fall off. On the other hand in the case of spray application, the hairy out-growths on leaves prevented the sprayed particles from penetrating into the mesophyll.

In general, for narrow leaved monocot and graminaceous weeds with a covering of hairy or other cuticular outgrowths, the dust application proved to be efficacious to large extent, while for large glabrous leaved dicot or monocot weeds, the spray applications were more effective.

Among the sprays applied, those which contained an adjuvant or spreader such as carbowax 1500, xylene etc, gave more stickiness and covering power on the leaf surface, thus effecting a greater penetration of the herbicidal chemical.

Owing to restricted supply of 2, 4, D acid and Karmex W, only small scale dusting could be done. Preliminary experiments proved that if the surface of the leaf is moderately wet to enable the powder to stick to the surface, the penetration of both the above chemicals would be more efficient.

(c) *Investigations on the residual and drift effect.* The residual effects of different chemicals sprayed on the soil were investigated by determining the time lapse required for proper growth of plants in the herbicide treated plots or pots. For the study of the residual toxic effects, similar concentrations of various chemicals in equal quantities were sprayed on the pots separately and the number of days needed for the emergence of healthy seedlings of *Melilotus alba* was determined. The results have been included in Table 94.

TABLE 94

Name of the Herbicide	Date of treat- ment	Concen- tration of spray	Nature of emergence of seedlings on							
			15-11-54	29-11-54	25-12-54	6-1-55	20-1-55	3-2-55	17-2-55	2-3-55
Dietox	4-11-54	0.1%	—	—	—	—	—+	+	++	++
Coronox D.	"	"	—	—	—	—	—+	+	++	++
2,4-D	"	0.02%	—	—	—	—	—	—+	—+	—+
Na-2,4-D	"	0.1%	—	—	—	—+	—+	+	+	+
Cornox M.	"	"	—	—	—	—	—+	—+	—+	+
Agroxone 3	"	"	—	—	—	—	—+	—+	+	++
M. C. P. A.	"	0.02%	—	—	—	—	—	—	—+	—+
Trioxone	"	0.01%	—	—	—	—	—	+	+	+

Duration of toxicity retained by soils sprayed with 20 c.c. of herbicidal solution per pound of soil according to *Melilotus alba* seedling emergence test, after definite intervals is shown, — indicates complete destruction, —+ poor or stunted growth, + almost normal growth as in the control ++ vigorous growth.

The drift effects were noticed chiefly through wind, water and soil. The drift effect of the chemicals was investigated by spraying a selected plot of land in windy conditions. The range of drift effect depended directly on the velocity of wind. The drift was, however, found to be more pronounced in dust applications. By spray treatment, the drift hazards to adjoining crops could be minimised.

Drift effect through the medium of water was investigated by spraying amine salt of 2, 4, D (Cornox D) and M.C.P.A. (Cornox M) in jute fields with stagnant water. The herbicidal toxicity was noticeable up to about 12 ft. from region of application.

Drift through the percolation of water through soil was perceived up to a maximum of 1½ ft.

D. MICROBIOLOGY

D. 1. Production of antibiotics by soil micro-organisms.

D.1.1. Survey of the *Actinomycetes* occurring in Kashmir soil

Soil samples collected from different parts of Kashmir were plated on Thornton's and Norris' media. Colonies were picked up on Ac-straw agar slants and studied.

About 17 soil samples have so far been plated and a total of 248 colonies picked up. The antibiotic activity of these strains were tested against both bacteria (*Staphylococcus aureus*, *Vibrio cholerae*, *Eberthella typhosa* and *Escherichia coli*) and fungi (*Fusarium vasinfectum*, *Helminthosporium sativum*, *Curvularia specifera* and *Aspergillus niger*) by agar-streak and agar-cup methods.

The following table gives the result of the screening test.

	No. of Anti-Gram positive strains	No. of Anti-Gram negative strains	No. of Antifungal strains
(a) Streak method	20	18	26
(b) Cup method	20	26	28

TABLE 94

Name of the Herbicide	Date of treat- ment	Concen- tration of spray	Nature of emergence of seedlings on							
			15-11-54	29-11-54	25-12-54	6-1-55	20-1-55	3-2-55	17-2-55	2-3-55
Dictox	4-11-54	0.1%	—	—	—	—	—+	+	++	++
Coronox D.	"	"	—	—	—	—	—+	+	++	++
2,4-D	"	0.02%	—	—	—	—	—	—+	—+	—+
Na-2,4-D	"	0.1%	—	—	—	—+	—+	+	+	+
Cornox M.	"	"	—	—	—	—	—+	—+	—+	+
Agroxone 3	"	"	—	—	—	—	—+	—+	+	++
M. C. P. A.	"	0.02%	—	—	—	—	—	—	—+	—+
Trioxone	"	0.01%	—	—	—	—	—	+	+	+

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Two very promising strains were encountered: one A6 (339) active against both Gram-negative and Gram-positive bacteria and another A8 (340) active against fungi only.

There were about twenty antibiotic-producing strains, the pigments being mostly brownish in colour on all the three media CDA, NA and Ac-straw,. In three cases the pigment was faintly violet on CDA.

Two strains A9 (351) and A2 (352) gave pigments with acid base indicating properties. Further work is in progress.

D.1.2. *Antibiotic Production by Bacteria*

(a) *Survey* : In the previous report a brief account of the survey of antibiotic producing bacteria of soils was given. This work had now been extended to 500 antibiotic-producing bacteria. On the basis of antimicrobial spectrum, 312 cultures which were found to be inhibitory, could be classified into 10 groups. Cultures exhibiting identical spectrum, however, may not necessarily elaborate the same antibiotic substance. To demonstrate this 100 positive cultures were selected and the culture filtrates were subjected to paper chromatographic analysis.

The cell-free culture filtrates were concentrated, and the aliquots then chromatographed by the descending method of chromatography using butanol-acetic acid-water as the developing solvent. This was then followed with bioautography. Distinct inhibition zones were visible around the part of the chromatogram which contained the active principle.

The active principles in most cases are heat stable. In a number of cases, R_f values in heated ones changed, though not the antibiotic property.

From the data obtained, it appeared that none of the antibiotic substances elaborated by the bacteria was identical with any of the five known antibiotics viz. bacitracin, subtilin, polymyxin, tyrothricin and circulin as indicated by antimicrobial spectrum and R_f values. The accompanying table will show the results obtained in the above experiments. Polymyxin alone has a broad antifungal spectrum but the R_f value is considerably different.

In seven out of one hundred culture filtrates bio-autographed, the R_f values could not be determined, and this is probably due to the poor solubility of the substances in water, resulting in little, if at all, transference of the active principle from paper strip to the agar medium.

(b) *Cultural conditions and Biochemical studies* : Observations involving some 12 cultures were made on the effect of shaking (aeration), depth of medium, temperature and pH. The results indicated that shake cultures were better for antibiotic production. The optimum temperature was 28 -30°C. Acidic condition was beneficial to antibiotic production. Maximum antibiotic titre was usually reached within 48 hrs. and the pH of the medium changed to 8.0 from the initial value of 7.0.

Four strains of antibiotic-producing bacteria were chosen for the study of the effect of incorporation of the vitamins and different C-sources, N-sources and "biological extracts" in a suitable basal medium. The results briefly are as follows—

Of the various sugars lactose gave the best results. Other sugars glucose, fructose, sucrose and maltose were utilised but not the pentoses—rhamnose and arabinose. The organic acids (malic, citric, succinic, fumaric and acetic) were better C-sources for growth and antibiotic production than the sugars. Among the amino acids only aspartic acid, glutamic acid and α -alanine supported good growth and antibiotic production. Antibiotic production was also enhanced with the vitamins (nicotinic acid, aneurin hydro-

TABLE
COMPARISON OF ANTIBIOTIC SPECTRUM AND R_f VALUES OF
KNOWN AND UNKNOWN SUBSTANCES

Known antibiotic substance	R_f value	Antibiotic activity (Inhibition zones in mm)		
		S.A.	E.C.	H.S.
Bacitracin	0.77	13.0	—	—
Subtilin	0.47	20.0	—	—
Polymyxin B	0.13	13.0	13	17
Circulin	0.06	14.0	15	—
Tyrothricin	0.80	15.0	15	—
<i>Unknown antibiotic substance</i>				
B_7	0.42*	12.0	—	25
	0.93			
B_{44}	0.81	15.0	—	25

— indicates no action.

S.A.—Staph. aureus, E.C.—Esch. coli.

H.S.—Helminthosporium sativum.

*—Two spots.

chloride, pyridoxin, Ca-pantothenate, inositol, riboflavin and biotin). Growth was however much poorer than those obtained with the organic acids and amino acids mentioned. Increase in the growth and antibiotic titre was also noticed when beef extract, soyabean meal, straw infusion or peptone hydrolysates were incorporated into the media.

(c) *Isolation of the active principles elaborated by B_7 .* From the large number of antibiotic-producing bacteria isolated, culture No. B_7 was chosen for isolation of the active principle elaborated by it. This was grown on sucrose-yeast-extract solution in shake culture. Several litres of the cell free solution were acidified with conc. HCl. Flocculent precipitates were formed which were centrifuged down and washed with several volumes of water. A part of this precipitate contained the active principles and the other part inactive. The active principles were resolved by (i) solvent extraction, (ii) counter-current distribution, (iii) adsorption chromatography and (iv) ion-exchange chromatography.

(i) *Solvent extraction* :—Butanol extract of the acid ppt. was dried and redissolved in a small volume of methanol containing traces of water. An equal volume of a mixture of petroleum ether (40-60), and benzene (1:1) was added and shaken. The process repeated with the lower layer several times and the active principle was further purified by precipitation* with ether. This precipitate on several washings and reprecipitation gave the pure product (I) which is a brick-red amorphous powder.

The upper petroleum ether-benzene layer and the petrol ether benzene washings from the previous expt. were pooled together and washed several times with ethanol and ether. After evaporation the residue was dissolved in ether and precipitated with water; a white powder (II) was obtained.

(ii) *Counter-current distribution*—Compounds (I) and (II) can be separated* by this method. The phases used were butanol saturated with 2N-NaOH and a mixture of methanol-petrol ether-benzene (9:22:2).

(iii) *Adsorption chromatography*—Better results were obtained through adsorption chromatography on alumina. A yellow pigment (III) as also (I) and (II) were obtained after elution with acidic butanol.

(iv) *Ion exchange chromatography*—Some interesting results were obtained with ion-exchange chromatography. Several cation and anion exchange resins were tried. IRA 120 in the chloride form gave the best results. Here also the three fractions (I), (II), (III) obtained on elution with increasing strengths of acetic acid, HCl and methanolic HCl.

(d) *Chemical and biological property* : The fractions were further purified by chemical analysis. Fraction (I) was supposed to be a polypeptide composed of aspartic acid, glutamic acid, serine, glycine, threonine, tyrosine, valine, leucine or phenylalanine, proline, arginine, and lysine. It was soluble in alkali, alcohols, chloroform, pyridine, acetone etc. and insoluble in ether, petrol ether, benzene, water and acids. It was highly fungistatic. It has a R_f value—0.93 in butanol-acetic acid-water (4:1:1).

Compound (II) was also a polypeptide composed of aspartic acid, glutamic acid, glycine, α -alanine, tyrosine, valine, phenyl alanine and 2 unidentified ones. This was also soluble in alcohols, pyridine and ether but insoluble in water, petroleum ether etc. This was also fungistatic but less active than (I). It has a R_f value 0.40 in butanol acetic acid-water.

The substance (III) was soluble in water, acetone, less so in ether and practically insoluble in chloroform. Its chemical composition as not been yet determined.

D. 2. Studies on the physiology of *P. vermiculatum* Dangeard

D.2.1. Role of nitrogen concentration on production of perithecia in *Penicillium vermiculatum* Dangeard

Sexual reproduction is sometimes dependent on a number of environmental factors. While some fungi normally pass on from the vegetative to the sexual reproductive state there are others which require specific factors for attaining such a state.

A strain of *P. vermiculatum* isolated in our laboratory produced perithecia when grown on 2% malt-extract medium, but gave only vegetative growth on synthetic modified Czapek-Dox agar (CDA) medium. Two percent malt agar and CDA when mixed in equal proportions did not also favour sexual reproduction. When any single ingredient of CDA was added to malt agar medium it was found that sexual reproduction was completely inhibited by NaNO_3 and partly by glucose. Other ingredients had no role. It was likely that concentration of NaNO_3 or glucose or of both played some part on perithecia formation.

By keeping the NaNO_3 level constant at 0.2% and varying the glucose from 0.5% to 5% in CDA, no perithecia was produced. But when glucose was kept constant at 4% and NaNO_3 concentrations varied (0.025, 0.05, 0.1, 0.2 and 0.4%) it was found that sexual reproduction was favoured at 0.05% and to a less extent at 0.1%. The other concentrations at 0.05% and to a less extent at 0.1%. The other concentrations of NaNO_3 did not favour perithecia formation. When NaNO_3 in CDA was replaced by several other nitrogen sources and their mixtures in various concentrations, it was found that the nitrogen concentration favourable for sexual reproduction was in the same range, viz. from 0.0082 to 0.0156% of *N*, corresponding respectively to 0.05 and 0.1% NaNO_3 .

D.2.2. Utilization of carbon and nitrogen sources by *Penicillium vermiculatum* Dangeard

Using a synthetic basal medium, a number of different carbon and nitrogen sources were respectively tried. After ten days' growth the mats were dried at 80° C for 24 hours and the dry weights taken.

Sorbose was found to be a poor source but all other hexoses employed were utilized, the order of preference being levulose, glucose, mannose and galactose.

Of the pentoses, xylose is a good source, L (+) arabinose comes next whereas d-arabinose was a poor source.

Mannitol is the best carbon source among the three sugar alcohols tried. Inositol was moderately good and dulcitol was not utilized at all.

Sucrose was best among the oligosaccharides and also the best among all the carbon sources tried. Maltose was also a very good source and lactose a poor one.

Among the polysaccharides, dextrin was the best, ranking equally with sucrose, inulin and glycogen were moderately good.

Of the different inorganic sources used, ammonium tartrate was better than sodium or ammonium nitrate.

Incorporation of amino-acids into the synthetic medium gave in many cases a better growth than the inorganic sources. Tyrosine was the best and serine the least utilizable, the order of preference being, tyrosine, valine, threonine, aspartic acid, arginine, proline, β -alanine, dl-alanine, cysteine, phenyl alanine, asparagine, glycine, leucine, tryptophane, lysine-methionine, serine.

TABLE
SHOWING THE AVERAGE DRY WEIGHT OF MYCELIA FROM A REPLICATE
OF FOUR FLASKS

Carbon Source	Mycelial dry weight in mg.	
	Concentration 1%	Concentration 2%
Glucose	40	80
Levulose	45	80
d(+) Mannose	30	69
Galactose	23	36
l-sorbose	9	16
xylose	41	98
L(+) arabinose	40	97
d-arabinose	23	36
Mannitol	50	72
Inositol	32	56
Dulcitol	3	8
d(+) raffinose	37	86
Maltose	43	112
Sucrose	57	115
Lactose	6	6
Inulin	42	74
Dextrin	61	115
Glycogen	35	57

TABLE
SHOWING THE UTILIZATION OF DIFFERENT NITROGEN SOURCES

Nitrogen source Concentration 0.033%N	Dry weight of mycelia in mg.
Sodium nitrate	82
Ammonium nitrate	63
Ammonium tartrate	118
Glycine	85
Tryptophane	100
Threonine	206
Valine	282
Leucine	82
Lysine	56
Cysteine	102
Proline	140
Serine	30
dl-Alanine	109
α -Alanine	138
Asparagine	98
Methionine	52
Arginine	163
Phenylalanine	101
Tyrosine	299
Aspartic acid	188

D.2.3. *Relation between NaNO_3 and glucose concentrations*

Varying the NaNO_3 and glucose concentrations the following result was obtained.

TABLE
SHOWING RELATION BETWEEN NaNO_3 AND GLUCOSE

Con. NaNO_3 in %	Conc. Glucose in %	Dry. wt. in mg.
1. 0.05% (.0082%N)	1	30
	2	40
	3	42
	4	40
2. 0.01% (.0165%N)	1	35
	2	78
	3	80
	4	75
3. 0.2% (.033%N)	1	36
	2	81
	3	140
	4	82

It is clear from the above results that for 0.05 and 0.1% of NaNO_3 , the optimum concentration of glucose was 2%, there being very little rise when glucose concentration was raised to 3% and concentration of 4% had adverse effect. When, however, the concentration of NaNO_3 was increased to 0.2% the optimum level of glucose also changed to 3% beyond which, again, the increase in concentration of glucose had an adverse effect.

D. 3. *Studies on the induced mutations in micro-organisms.*D.3.1. *Production of nutritional mutants in *Aspergillus niger* van Tieghem*

The spores after irradiation with UV (2537 Å) (as reported earlier) were plated in minimal medium Czapek-Dox as modified by Clutterbuck and others which had the following composition. NaNO_3 —3 gm; KCl—0.5 gm; $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ —0.5 gm; $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ —0.01 gm; KH_2PO_4 —1 gm; glucose—40 gm; agar—20 gm; distilled water 1 litre; pH 6.

After 48 hours of incubation at 28° C the minute colonies were noticed. 5 c.c. of a complete medium having the following composition was then poured over the minimal medium :—casamino acids—1.5 gm; yeast extract—1 gm; peptone—1.5 gm. corn steep liquor—10 gm; and 3 c.c. solution of B-complex vitamins, glucose—20 gm agar—20 gm, dist. water 1 litre, pH 6. Vitamin solution contained the following ingredients, dissolved in 20 c.c. distilled water—riboflavine—10 mg., calcium pantothenate—20 mg. nicotinic acid—10 mg., pyridoxine hydrochloride—5 mg., biotin—0.025 mg, aneurin hydrochloride—5 mg. The plates were again incubated and new growing colonies were picked up on complete medium slants.

The isolates growing on complete medium were again transferred to minimal medium. Cultures unable to grow in minimal medium at this stage were picked up finally as nutritional mutants. Out of 1875 colonies isolated, 25 proved to be nutritional mutants. Work is in progress and other aspects of nutritional requirements are being studied.

D.3.2. *Ultraviolet light induced mutations in a Streptomyces sp (A₁₂).*

The *Streptomyces* strain A₁₂ (producing a new antibiotic pigment Rubidin reported earlier) was subjected to ultraviolet irradiation with a view to develop improved strains for the production of the pigment.

Suspension of spores from 10 day old slants was made in calsolene (1:10,1000) thoroughly shaken and filtered through sterilized cotton wool to remove spore clumps. The suspension was so diluted as to contain 6×10^6 spores, per c.c. Four c.c. quantities were distributed in 9 cm. petridishes and irradiated for 20, 40, 60, 80 and 100 seconds at a distance of 26 cm. from the lamp. The following table shows the rate of killing and per cent survival.

TABLE

Time of irradiation in Sec.	No. of Survivals Average/c.c.	Survival %.
0. (Control)	2.9×19^6	100
20.	1.7×40^6	58
40.	6.4×10^5	21
60.	3.5×10^4	1
80.	1.9×10^3	0.06
100.	5.9×10^2	0.01

D. 4. Industrial fermentation

D.4.1. *Design, set up and standardization of 10 litre fermenter for antibiotic production*

The body of the fermentation vessel is made up of 12 gauge, 18/8, quality Ti-stabilized stainless steel sheet, fitted with flanged cover secured by swing bolts and eye nuts. The fermenter is jacketed upto 2/3 its length with stainless steel cover and there is 1 inch space in between the wall of the jacket and fermenting vessel. There are inlet and outlet valves for circulation of steam or water on both sides of the jacket. The bottom contains another valve used for draining off water etc., from the jacket. The vessel cover has 8 port holes, of which the central one is fitted with a stainless steel shaft having turbine type agitators with impellers. The remaining holes carry the following equipments :—

(a) Air-inlet valve, (b) sampling line, (c) air-outlet valve with pressure gauge, (d) thermometer hole (e) steam outlet valve (f) inoculation and antifoam nozzle (g) electronic level recorder.

All the above openings are fitted with stainless steel valves. Temperature of the vessel is controlled by circulation of water through the jacket.

The compressed air (from a compressor) is passed through a rotameter and Aerox air filter assembly. Finally the air free of micro-organisms is led into a $\frac{1}{2}$ inch pipe line upto air-sparging nozzle.

Sterilisation of the medium is done inside the fermenter. The medium is prepared and poured into the vessel through the inoculation nozzle. The lid is bolted down with nuts and the following valves are kept open in sequence.

- (1) Inoculation nozzle valve.
- (2) Air outlet valve.
- (3) Steam exit valve of the jacket.
- (4) Air inlet valve.

Steam is forced into the jacket at 30 lbs. to raise the temperature of the medium. When the medium boils at 100°C. steam passes out freely through the inoculation nozzle. After a few minutes the air outlet and the nozzle valves are closed and the medium is sterilised. The steam is also passed through the air circuit to sterilise this pipe line. The pressure of the fermenter is indicated by the pressure gauge.

When the fermenter has been cooled down to a temperature sufficiently low for growth, the inoculum is added through the inoculation nozzle, antifoam mixture is also added through the same from time to time as required.

The apparatus could be emptied through the sampling line by upward flow of the liquid and this is done by increasing the air pressure inside the valves.

The work is in progress and at the moment the apparatus is being standardised using Rubidin-producing strain A₁₂.

D. 5. Studies on counter-current distribution

D.5.1. Separation of indole acids

To the biochemists the separation of indole acids has been of considerable interest because of the important role played by them as plant growth hormones.

A mixture of indole acetic acid, indole propionic acid and indole butyric acid were separated in a 24-tube counter-current distribution apparatus. Mutually saturated phosphate buffer (pH 9.6) and ether were used as distributing solvents. Estimations were made colorimetrically using Tang and Bonner's reagent as developer.

Partition coefficients of the indole acids in this system, as studied from the counter-current distribution bands, were in the increasing order as indole acetic acid, indole propionic acid and indole butyric acid.

D.5.2. Determination of homogeneity of a phenolic compound

A phenolic compound obtained from *Mesua ferra* Lin. in the Department of Chemistry Bose Institute, was run in a 24 tube counter-current distribution apparatus to prove its homogeneity. The crude product was previously purified by repeated crystallisation from benzene and methanol.

The solvent pair used for distribution consisted of mutually saturated benzene and ethylene glycol and estimations were made colorimetrically.

Analysis of the distribution band showed that the coloured material showing its appearance from the 13th tube, had its peak at the last tube and thus rendering it impos-

ible to draw its theoretical distribution curve. Colourless fractions obtained from the 0th to 12th tube on evaporation gave no residue, indicating the absence of any colourless component in these tubes.

Further work by distributing the phenolic compound with a larger number of transfers and by adjusting optimum partition coefficient by mixing suitable volume of petrol ether with benzene phase is now contemplated.

D.5.3. *The role of salting out effect in counter—current distribution*

So far as our knowledge goes the interesting role of salting out effect phenomenon has not been previously studied by any worker in this line.

This interesting phenomenon was studied in case of counter-current distribution of a mixture of antibiotics (containing both coloured and colourless components), obtained in our laboratory from the bacterial strain B₇, in a ternary solvent system, viz., methanol (9 vols.): petrol ether (22 vols.) and benzene (2 vols). It has been found that though the coloured fraction was practically not partitioned at all into the upper phase and ought therefore to remain in the 0th tube throughout the operation, still it was distributed in the first 6 and 12 tubes for 23 and 115 transfers respectively, the last 92 transfers in the latter case being carried out by the single withdrawal technique.

Unfortunately, the colourless fraction, having its distribution by the usual partition phenomenon, could not be completely separated from the coloured fraction, which was not at all partitioned between the solvent phases; the resolution of the two peaks was not possible in this case, as seen from the distribution bands obtained by gravimetric and bio-assay method, giving only one peak in each case. But partial separation was realised when the distribution bands obtained by gravimetric method, comprising weights of both of the coloured and colourless antibiotics, are compared with those obtained by colorimetric method.

The mechanism of the distribution of the coloured antibiotic was studied and the nature and peak of the distribution band were explained by the salting out effect phenomenon. A mathematical derivation of this interesting effect in counter-current distribution is in contemplation.

D.5.5. *Mass effect in counter current distribution*

Effect of mass of the distributed material in counter-current distribution apparatus was reported previously (Vide Annual Report 1955). A new interesting phenomenon was observed in an exhaustive study of the distribution bands of the dyes methylene blue and neutral red between butanol and 1% HCl.

It was found that in case of a mixture when distributed in counter-current distribution apparatus, the absolute position of the peaks of the distribution bands of the components may be changed due to mass effect leaving their relative position unaltered. The method of recognising the components in a mixture by the relative position of the peaks in a distribution bands thus gained strong ground.

E. ZOOLOGY

E. 1. Precocious metamorphosis induced by thyroxine in the tadpoles of

Bufo melanostictus

So far the larval states of two species of frogs *Rana tigrina* and *Bufo melanostictus* have been influenced by the action of antibiotics like penicillin which can retard the metamorphosis of *Rana tigrina* by about seventeen months—these animals in the prolonged larval state have not shown indication of a sexual cycle. Treatment of penicillin retarded larvae of *Bufo melanostictus* by dilute thyroxine (1/8 mgm in 4000 cc. of water) solution has produced a precocious metamorphosis in which the animal takes the form of a tailed froglet with the breathing habits of the larva. The metamorphosed animals resemble miniature salamanders crawling and sometimes swimming under water; they never rise to the top of the water to breathe air. It has not been possible to keep these animals alive more than 22 days, probably because these precociously transformed larvae have the preying and devouring mechanism of land frogs and they do not find suitable food materials under water. Efforts have been made during the previous year to find suitable food materials for them so their lives may be prolonged under water as long as possible.

The young frogs, just after transformation, come to the land and hop about in search of prey in the form of slow moving minute insects. They never touch any dead insect or any decomposed matter. Even within an easy reach they would not attempt to prey upon a living insect if it remains stationary. Any slight movement attracts the frog's attention and instantly it will be snapped into its mouth and devoured as a whole. The remodelled mouth parts of the precocious tailed froglet are also adapted to this mode of preying. So some slow-moving thread-like red organisms were introduced in the water in a jar, containing 11 tailed froglets. These organisms are known as tubifex. They live in clusters in shallow pools and having attached themselves to the bottom always move their tails in a peculiar fashion. Very often the tailed froglets were found to be crawling near about those organisms but seldom attempted to snap at them. They seemed to be too big for these animals. So one after another all of them died of starvation within 5 or 6 days.

Experiments were started again with 10 newly metamorphosed tailed froglets. They were put in two vessels, each containing 5 of the specimens. This time *Daphnia* and some other minute aquatic insects were introduced into the vessels. But the results were not satisfactory, as these aquatic insects are too fast to be preyed upon by these slow-moving animals. Out of 10 specimens 2 died earlier within 8 days and the rest of them died after 17 days almost simultaneously within a day or two.

Further attempt was made to rear the tailed froglets in vessels containing old aquatic plants partially covered with slimy substance. These aquatic plants are infested with numerous animalcules, such as rotifer, stentor, vorticella etc. These animalcules attach themselves to the decaying leaves of the plants and collect food by peculiar ciliary move-

ments. Some of these animalcules are big enough to be seen easily and preyed upon by the tailed froglets. Experiments were started with 40 specimens of tailed froglets in 4 batches by the end of August, 1956, but has to be discontinued after a few days owing to some unavoidable circumstances. However, it will be repeated again in the ensuing rainy season when tadpoles will be available.

E. 2. Actions of thiourea and penicillin on the tadpoles of *Rana tigrina*

Attempts were made to make a comparative study on the action of thiourea and penicillin on the metamorphosis of tadpoles (*Rana tigrina*) and to observe the effect of vitamin B₁₂ on the thiourea treated tadpoles.

It has been found that penicillin delays the metamorphosis up to a maximum period of 17 months by its bacteriostatic and bactericidal action on the vitamin B₁₂-producing bacteria in the intestine of tadpoles, whereas this effect can be counteracted by vitamin B₁₂, i.e. this vitamin is able to initiate the metamorphosis of the retarded tadpoles within about 10 to 15 days. It is probable, therefore, that vitamin B₁₂ deficiency is produced in penicillin treated larvae owing to the inhibitory action of the antibiotic on the growth of the vitamin B₁₂-producing bacteria in the intestine and due to this deficiency the metamorphosis is delayed and it cannot take place without the action of thyroid hormone. It can be assumed that in penicillin treated tadpoles the thyroid gland is depressed and the application of vitamin B₁₂ overcomes the depressed activity of the gland. It can be also presumed that vitamin B₁₂ either initiates or activates the production of thyroxine in tadpoles and with this idea attempt was made to depress the thyroid gland by anti-thyroid drug, thiourea and to observe whether vitamin B₁₂ counteracts the anti-thyroid effect of thiourea or not.

It is known that thiourea is responsible for the inhibition of biosynthesis of thyroid hormone by interfering with the activity of the peroxidase enzyme system which is mainly concerned in the thyroid gland with the formation of thyroxine. Naturally, if the production of thyroid hormone is largely retarded by the administration of thiourea in tadpoles, the metamorphosis of these larvae would be retarded.

The tadpoles were collected from local tanks and allowed to develop in tap water containing water weeds (hydrilla) for a few days in the laboratory. No additional food was given to them during this period.

Four batches of tadpoles (each batch containing 25 tadpoles) were treated with thiourea solution (0.05 per cent) and the other four batches (with the same number of larvae in each group) with penicillin solution (80 units per c.c.). 100 tadpoles were kept as control.

The actions of thiourea and penicillin on the metamorphosis were being observed.

Out of the total number of tadpoles taken in penicillin treated groups only 20 tadpoles died during the period of experiment. Out of the surviving 80, 70 tadpoles metamorphosed at the end of eight months and only 10 tadpoles did not undergo metamorphosis during this period.

In thiourea treated groups not a single tadpole metamorphosed at the end of eight months, only 25 larvae died during this time. The other peculiarity is that the tadpoles in penicillin-treated groups grew in size to some extent, whereas the growth of the larvae in thiourea treated batches was completely checked. It is evident, therefore, thiourea has a greater metamorphosis-retarding action than penicillin though their mechanism of action is different.

The retarded tadpoles of the thiourea and penicillin treated groups were treated with vitamin B₁₂ (1.6 g/100 ml.) but satisfactory results were not obtained possibly due to low temperature in winter season.

E. 3. The effect of thiourea on the phosphatase content of thyriod gland of rats was studied

Six albino rats were treated with thiourea and six were kept as control. 0.2% thiourea mixed with the diet of the animals was used. The two groups were kept under same conditions. After treatment for thirty days the rats were killed and their thyroids were dissected out and studied for phosphatase content by Gomori's revised Histochemical Method for phosphatase. It was noticed that the alkaline phosphatase content of the thyriod glands of thiourea treated rats was greatly reduced than that in the thyriod glands of control rats. The same result was also obtained for acid phosphatase. The investigation is being continued.

WORKSHOP

During the year (1956-57) 477 requisitions for different types of jobs were received from different departments and almost all of them were completed. The following is a list of major works which were taken up for the manufacture in the workshop.

1. For Neutron monitor and Meson telescope the following components were made.

(a) One Camera for taking the photographs of a panel on which two call counters, one clock and a Barograph are mounted. The camera is electrically operated and is run by a clock work mechanism which energise a plunger magnet for driving the film, shutter and flash lamps at every 15 mts. interval.

(b) Brass counters and glass copper joints for the same.

(c) Pile consisting of lead and paraffin blocks and other accessories as per specifications supplied by IGY Committee.

2. Assembly of an electron collection ionization chamber having suitable polystyrene gaskets and insulators for central collecting electrode.

3. Spherical symmetry apparatus :

It consists of hollow concentric aluminium leak proof spheres, the inner one having a cylindrical chamber for holding the source. These spheres are held vertically and rotated on its own axis at a speed of 1 r.p.m. Another aluminium disc with two arms having arrangements for holding foils of different materials is rotated around the sphere on an axis at right angle to the axis of the spheres at a speed of about 1000 r.p.m.

4. Anticoincidence counter assembly.

5. Proportional counter assembly.

6. Liquid scintillation counter.

7. Photomultiplier casing and the assembly.

8. Modification of a cylindrical cloud chamber.

9. Rectangular shaped cloud chamber of dimension $3' \times 2'-6" \times 1'-6"$.

10. Apparatus for ultrasonic investigation for which the following components were made.

(a) Rotating sector with adjustable aperture.

(b) Acoustic interferometer having micrometer head to read up to .0001 m.p.m.

(c) Special type of Photocell housing fitted with a double acting micrometer slit.

11. Gas chromatography apparatus in progress.

12. One shaker consisting of two trays having capacity to hold conical flasks. The trays have been made of aluminium and perspex in order to admit light from all sides from fluorescent tubes fitted at the top and bottom of the shaker.

13. One stainless steel hood with sliding doors fitted with suitable exhaust fans and fluorescent light inside specially built for the work of radioactive isotopes.

14. To utilise the exhaust water from the condensers an water cooler has been constructed and installed in the Organic Chemistry Laboratory in which exhaust water from a set of condensers is cooled down to a temp. about 4°C and recirculated.

15. Remodelling and putting into commission of a Fermenter of Microbiology Department.

16. In gas blowing section quite a large number of G.M. counters were made. One glass apparatus for filling up BF_3 counters have been made.

17. In carpentry shop besides various works in connection with research and maintenance a large number of furnitures were made for the Institute.

At Shamnagar experimental station, one 3" tube well has been sunk. One 5 H.P. diesel pumping unit has been installed there to pump out water for irrigation of lands.

At Falta another 5 H.P. Diesel pumping set has been installed on a trolley for pumping water to irrigate the land under cultivation.

Besides these, regular maintenance of motors, refrigerators, air conditioning units, Diesel engines, Petrol engines and pumps were done as usual.

During this year one modern Universal Milling Machine and a precision Lathe with Turret head have been installed in the workshop. We hope to add one universal grinding machine and a Radial Drill in order to make the workshop well equipped for all kinds of jobs.

LIBRARY

The Library consists of 4156 volumes (2,069 books and 2,087 periodicals). During the year under report 301 volumes (128 books and 173 periodicals) were added to the stock against 248 during the previous year. The total number of periodicals received was 172 (inland 57 and foreign 115) out of which 85 were subscribed and the remaining 87 were received in exchange of Institute publications. The Library also received a large number of technical pamphlets, circulars, reprints, annual reports, etc., from various research institutions and Government Departments, both inland and foreign.

Due to the increase in the number of research staff in the Institute and the growing number of outside research workers, the volume of work in the Library has also increased considerably and it was felt necessary to strengthen the Library staff by the appointment of an Assistant Librarian to cope with the situation. Further, for providing better reading facility to readers it was decided to keep the Library open for 60 hours a week from next year—from 9 A.M. to 8 P.M. on weekdays and from 9 A.M. to 3 P.M. on Saturdays.

With the rapid increase of readers there has been a pressing demands for more books and journals in the Library. It could be partially met by purchasing some very important books and adding a considerable number of important periodicals in the current subscription list of periodicals. Efforts are also being made in a planned way to provide more

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Due to the increase in the number of research staff in the Institute and the growing number of outside research workers, the volume of work in the Library has also increased considerably and it was felt necessary to strengthen the Library staff by the appointment of an Assistant Librarian to cope with the situation. Further, for providing better reading facility to readers it was decided to keep the Library open for 60 hours a week from next year—from 9 A.M. to 8 P.M. on weekdays and from 9 A.M. to 3 P.M. on Saturdays.

With the rapid increase of readers there has been a pressing demands for more books and journals in the Library. It could be partially met by purchasing some very important books and adding a considerable number of important periodicals in the current subscription list of periodicals. Efforts are also being made in a planned way to provide more

money in addition to increased recurring grant during the Second Five Year Plan period for the purchase of a good number of important books and journals to meet the requirements of the readers and to establish a resourceful up-to-date research library.

PUBLICATIONS

During the year under report Vol. 19 (1952-54) of the *Transactions of the Bose Research Institute* has been published and Vol. 21 (1956-57) is now in the press and will be published soon.

Efforts are being made to reprint some of the out-of-print works of Sir J. C. Bose, viz., "Response in the Living and Non-Living", "Plant Response", "Researches on the Irritability of Plants", etc., in the near future. Other publications during the year under report include (1) Annual Report 1955-56 and (2) The Eighteenth Acharya Jagadish Chandra Bose Memorial Lecture on "The Frontiers of Biology" by Dr. A. C. Ukil with the Director's Report.

Gm

APPENDIX A

I. Governing Body :

Dr. Debendra Mohan Bose
Mr. Sudhansu Mohan Bose
Mr. Kedarnath Chatterjee
Mr. Sudhir Kumar Mandal
Prof. Sisir Kumar Mitra
Mr. Abani Nath Mitter
Dr. Basanti Dulal Nag Chowdhury
Mr. Bhupati Mohan Sen

II. The Council :

Mr. S. M. Bose
Mr. K. N. Chatterjee
Mr. S. K. Mandal
Prof. S. K. Mitra
Mr. A. N. Mitter
Mr. B. M. Sen

} Nominees of the Governing Body

Dr. D. M. Bose, Director, Bose Institute (Ex-officio)
Sri R. K. Ramadhyani, I.C.S., Secretary to the Govt. of India, Ministry of Natural Resources & Scientific Research. (Nominee of the Central Government)

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

Dr. P. Parija, D.Sc., F.N.I., I.E.S. (Retd)
Vice-Chancellor, Utkal University

Dr. K. Ahmed Chowdhury, D.Sc., F.N.I.
Professor of Botany, Aligarh Muslim University.

} Scientists nominated by the Central Government

Mr. Nandadulal Sreemany (Representative of the Calcutta Corporation)

III. Finance Committee :

Mr. B. M. Sen (Chairman) (Representative of the Council)
Mr. S. Natarajan, Accountant General, West Bengal
Dr. D. M. Bose (Ex-officio)
Mr. A. K. Ghosh (Secretary) upto 29.12.1956
Dr. S. K. Roy (Secretary) from 30.12.56

IV. Building Committee :

Dr. D. M. Bose (Ex-officio)
Mr. K. N. Chatterjee (Representative of the Council)
Mr. A. N. Mitter (Representative of the Governing Body)
Mr. A. K. Ghosh (Secretary) upto 29.12.56
Dr. S. K. Roy (Secretary) from 30.12.56

Gum

APPENDIX B

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

Registrar : Mr. A. K. Ghosh, M.Sc., M.M.G.I. (on leave from 29.12.56)

Actg. Registrar : Dr. S. K. Roy, M.Sc., Ph.D. (Lond) D.I.C (from 29.12.56)

Department of Physics :

Head of the Department : The Director

Research Assistant : Mr. T. C. Bhadra, M.Sc.,

A.E.C. Junior Research Fellow : Miss Nilima Basu, M.Sc.,

Attached worker : Prof. H. P. Dey, M.Sc., P.R.S.

Department of Chemistry :

Head of the Department : Dr. P. K. Bose, D.Sc., F.N.I.

Research Fellow : Dr. A. Sen, M.Sc., Ph.D. (Leeds)

Dr. D. P. Burma, M.Sc., D.Phil (on study leave)

Dr. S. P. Sen, M.Sc., D.Phil.

Research Scholars : Mr. D. P. Chakraborty, M.Sc.,

Mr. S. Pattabi Raman, M. Sc. (from 24. 7. 56)

National Research Fellow : Dr. A. K. Barua, M.Sc., D.Phil (from 1.6.56)
(Govt. of India)

Govt. of India Senior Scholars : Mr. J. Dutta, M. Sc.,

Mr. K. Venkateswara Rao, M.Sc.,

Mr. S. K. Chakraborty, M.Sc.,

Govt. of India Junior Scholar : Mr. A. K. Banerjee, M. Sc.,

Attached workers : Dr. S. N. De, M.B., D.T.M., Ph.D. (Lond)

Dr. P. C. Maity, M.B.B.S.

Dr. K. Mukherjee, M.B.B.S.

Department of Botany :

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

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

Statistician : Mr. A. K. Roychowdhury, M.Sc. (From 16.2.57)

Research Assistant : Mr. B. K. Datta

Mr. A. T. Guha Thakurtha

Mr. A. K. Adhikary, M.Sc. (also farm Superintendent)

Research Scholar : Mr. B. B. Biswas, M.Sc. (from 1.12.56)

Mr. V. N. Gadgil, M.Sc.

Mr. V. S. Sarma, M.Sc.

Mary & Richard Keating Mrs. Mridula Datta, M.A., (upto 21. 9. 56)

Student : Miss. Chitra Ghosh (from 22.9. 56)

Govt. of India Junior Scholar : Miss. Mary Korah, M.Sc.,

National Research Fellow : Dr. Sunanda Bose (on study abroad)

Attached workers : Mr. D. K. Chakraborty, M.Sc. (R. G. Kar Medical College)
Miss. Madhuri Dutta, M.Sc., (Lady Brabourne College)
Miss. Maharani Chakraborty, M.Sc.,

Department of Microbiology :

Head of the Department : Dr. P. N. Nandi, M.Sc., Ph. D. (Lond) D.I.C.
Sir J. C. Bose Scholar : Sri A. K. Banerjee, M. Sc., (upto 31.6.56)
Birla Scholar : Mr. A. K. Das Gupta, M.Sc., (upto 31.11.56)
Govt. of India Junior Scholar : Mr. Ajit Kumar Mishra, M. Sc. (upto 31.7.56)
Miss Mira Purkayastha, M.Sc.
Research Scholar : Mr. Ajit Kumar Mishra, M.Sc. (from 1.8.56)

Department of Zoology :

Research Assistant : Mr. G. C. Bhattacharjee
Govt. of India Senior Scholar : Mr. A. K. Medda, M.Sc. (from 1.6.56)

Workshop

Mr. M. L. Chatterjee, Workshop Superintendent
Mr. S. R. Ghosh, Workshop Superintendent (Electronics and Refrigeration)

STAFF APPOINTED UNDER GRANT-IN-AID SCHEMES

A. Board of Research on Atomic Energy

(*Investigator in charge :* Dr. D. M. Bose)

Scheme No. I-A Cosmic Ray Investigation :

Dr. S. D. Chatterjee, D.Sc. (*Honorary*)
Dr. M. S. Sinha, D.Sc., (*Research Officer*)
Mr. I. L. Chakraborty, M.Sc. (*Junior Research Assistant*)
Sri N. C. Das, M.Sc. -do- -do- (upto 14.9.56)
Sri S. N. Sen Gupta, M.Sc. -do- -do- (from 2.8.56)

Scheme No. I-B Nuclear Physics Investigation :

Mr. A. M. Ghosh, M. Sc., (*Junior Research Assistant*)
Mr. N. K. Ganguli, M.Sc., -do- -do-

Scheme No. II Neutron Generator Investigation :

Mr. A. N. Banerjee M.Sc. (*Junior Research Assistant*) (upto 14-12-56)

Scheme No. III Use of C^{14} & P^{32} as tracers in Photosynthesis & Plant Genetic Investigation : (upto 30.11.56)

Mr. B. B. Biswas, M.Sc. (*Junior Research Assistant*)
Mr. R. K. Basu, M.Sc., -do- -do- (upto 15.5.56)

Scheme No. IV Investigation on the induced mutagenesis in crop plants using X-rays & radioactive Isotope :

Mr. Amal Kumar Bose, M.Sc. (*Junior Research Assistant*) (from 16.5.56)

B. 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., Botanist (upto 30.4.56)

Mr. U. K. Rai, M.Sc., -do- (from 1.5.56)

Mr. Ramendra Nath Mukherjee, M.Sc., Assistant Botanist (from 1.5.56)

Mr. N. C. Saha, M.Sc., Chemical Assistant.

C. Indian Council of Agricultural Research :

Control of Weeds (Investigator in charge : Dr. K. T. Jacob)

Mr. K. George, M.Sc., Asstt. Botanist (upto 3.7.56)

Mr. M. G. Srivastava, M.Sc., Asstt. Botanist

Mr. A. P. Mani, M.Sc., Asstt. Botanist (from 14.9.56)

D. Council of Scientific & Industrial Research :

Studies on the production of antibiotic substance by *Streptomyces* spp.

(Investigator in Charge : Dr. P. N. Nandi)

Mr. S. B. Ghosh, M.Sc. (Junior Research Assistant)

Mr. P. P. Mukherjee, M.Sc. -do- -do- (from 8.5.56)

E. National Institute of Science, I.C.I. Fellowship :

Biological Research :

(Investigator in charge : Dr. D. M. Bose)

Mrs. Mridula Datta, M.A., (from 10.9.56)

Cam