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FIFTY-FOURTH INDIAN SCIENCE CONGRESS
HYDERABAD, 1967

ADVANCE NOTES ON SYMPOSIA & DISCUSSIONS
SECTION OF AGRICULTURAL SCIENCES

President :—BISWANATH SAHU, Ph.D.

I. "MUTATION BREEDING IN RELATION TO CROP IMPROVEMENT"

- ✓ 1. BALARAM MAJUMDER (Calcutta) : *Studies on the desirable mutants of rice induced by X-ray and ³²P.*

In recent years induction of mutations in rice have drawn a considerable interest. As a result number of mutants have been isolated in rice which can help in the improvement of the crop. In this laboratory desirable characters in rice have been induced by X-ray and ³²P.

One mutant (S.1) was induced in aus paddy (Marichbati variety) after ³²P, which gives higher yield and higher tiller number than the parent. The yield trial was conducted in different years and in two locations namely Falta and Shyamnagar Experimental Station.

The selection S.240 is a straw stiffed mutant, induced by X-ray, which is shorter in height and lower in yield than the Parent (Dular variety). Another straw stiffed mutant, (S.417) which is very low yielding in comparison to the parent variety.

Early flowering mutant (S.369) has been induced by ³²P in a variety of boro paddy (Chinsura Boro II), which is 9 days early then its parent type. This earliness is associated with reduced yield.

One mutant, S.221, of Marichbati variety that has been induced by X-ray treatment has taxonomic important. The number of lemma, palea, anther and ovary and kernel have increased than the normal. Because of this alteration in the floral morphology this mutant (S.221) can be recognized as a new mutant variety.

- ✓ 2. H. B. PATNAIK and B. MISRO (C.R.R.I., Cuttack) : *The simultaneous occurrence of three kinds of seven gene mutations in the X-ray treated rice.*

In the X₂ generation of an X-ray irradiated, *indica* rice, three off-type plants appeared in one progeny. The first was a grassy dwarf, which bred true in X₃ generation. The second and third had 30 and 31 ear-bearing tillers respectively and their X₃ progenies gave similar type of segregations consisting of (a) tall, broad-leaved and low-tillering type like the parent, (b) tall, high-tillering and broad-leaved types as in X₂ generation, (c) the swarf, narrow-leaved, grassy type as in X₂ and (d) the tall, narrow-leaved, high-tillering type.

Three recessive gene mutations for narrow-leaf, two recessive gene mutations for swarfing and one dominant gene mutation for high-tillering might have occurred simultaneously in X₁ generation and at least three of these genes involving the three

Difficult
to get high
yielding
mutant

new characters were found to be linked with one another. It would appear that apart from the possibility of obtaining economically useful mutants, irradiation studies might also aid in the formulation of linkage groups and in distinguishing pleiotropy from close linkage.

3. S. SAMPATH (C.R.R.I., Cuttack): *Planning and organising mutation breeding of rice.*

Part 1. *A new project in rice varietal improvement.*

For crop improvement through mutation breeding it is necessary to formulate provisional answers to the following questions. What genotypes are to be subjected to mutagenesis; what agent and dosages are to be used; and what should be the selection and breeding procedures? The problem can be usefully discussed with reference to a difficult project of breeding rice varieties to lowlying areas in the deltas of large rivers of India. It is desirable that a germ plasm collection from such inundation areas of Cambodia, Thailand, Burma and India be made, their testing made under representative conditions and the factors limiting production determined. This would need a coordinated effort, of botanists, agronomists, soil chemists and possibly engineers. Only after the requirement in plant type is formulated, can be mutation breeding be started.

Part 2. *New techniques in mutation breeding.*

(a) Haploid plants are found rarely in segregations from "wide" crosses in rice. Such haploid plants can be kept alive and multiplied by vegetative propagation. Diploid sectors often arise when the clone is subjected to high summer temperatures. By subjecting the haploid to mutagenesis and subsequently securing the diploid it will be possible to compare the different homozygotes which would arise from the random effect of the mutagen on the different growing points. Three different haploid cultures are being maintained at the Central Rice Research Institute and the mutagenic effect of Monazite sand is being tested.

(b) Subjecting rice seeds to ionising radiations results in occasional "re patterning" of the chromosomes. Such rearranged genomes are of potential use in synthesis of fertile tetraploids. From the progeny of Neutron irradiated Assam 35 a freak dwarf was isolated. This dwarf was to be used for hybridisation but is highly sterile. Search showed that this occurred as a simple mendelian segregation and the heterozygous plant was of normal growth and fertility. The heterozygote could however be identified by a slight pollen sterility as compared to the normal Assam 35 plants. The heterozygote is being used for crossing with other variant genotypes. A similar technique could be used for picking out translocation homozygotes.

4. M. P. SINGH (New Delhi): *Mutation breeding in bread wheat (Triticum aestivum).*

Hugo de Vries (1901) gave the idea of producing artificial mutations and utilizing them for breeding desirable cultivated plants. But, it was H. J. Muller (1927), who for the first time demonstrated the role of ionizing radiations in induced mutations. The viability of monosomics, nullisomics and of various deficiency duplication gametes in wheat, makes it an ideal material for mutation studies. Hence, the present mutation breeding project was started to incorporate certain desirable characters in three well adapted hill varieties of bread wheat, Ridley, N.P. 829 and N.P. 770. Seeds with moisture content of 9-10% were subjected to different dosages of X-rays, gamma

rays (acute and chronic both), Thermal neutrons, fast neutrons and radioisotopes (P^{32} and S^{35}).

The critical study on mutation rate, mutation spectrum, RBE of different mutagens, screening and selection of mutant with desirable attributes was undertaken in full details. Based on experimental results and observations, following conclusions were drawn :

(i) Mutation spectrum remained the same in all the three varieties irrespective of the treatment and dosage.

(ii) Chronic irradiation was most effective in producing maximum number of mutations, as measured on the basis of total population, percentage of segregating families and percentage of mutations per M_1 family.

(iii) M_3 gave the maximum range of variability, which helped in selection of desirable mutants which included fully bearded, erectoids, early maturing, giant ear and resistant types etc.

(iv) Yield trials laid at different places to evaluate the scope of induced F.B. in Ridley have clearly shown that, in maturity, height, mean tiller number, grain number per spikelet, 1,000 grain weight, single plant yield and in protein content etc., the mutant selection compares well with the control.

The results obtained in the course of present investigations demonstrate that mutation breeding offers an immense scope in wheat improvement particularly when the desired character is governed by one or two genes.

5. P. K. GANGULI (Viswa-Bharati) : *Mutation studies in green gram (Phaseolus aureus Roxb.)*.

Out of two doses of X-rays—30,000 r and 60,000 r used for irradiating dry seeds of green gram, variety T_1 , 60,000 r proved to be sublethal. In thermal neutrons, out of three doses— 4×10^{22} n.p./cm², 6×10^{22} n.p./cm² and 8×10^{22} n.p./cm², the last dose was found to be sublethal. There was reduction in height, and fertility of the R_1 plants in all the treatments.

The different mutant types recovered in R_2 and later generations were classified into 3 main groups—(a) Chlorophyll deficient, (b) sterile or fruitless, and (c) vital. These were further classified into morphological, anthocyanin and other types.

In the wide range of mutations of green gram, fertility and viability were mostly affected irrespective of whether morphological changes were associated nor not in them. Green gram can withstand gross morphological changes and its morphological system is less rigid. However, many of the mutants improved their fertility and vigour in R_3 and R_4 generations. The environmental factors have been found to influence the expression of the mutants character to a considerable extent. Several mutants showed increased vigour and gave higher yield when crossed with the control plants. Several selected mutants of improved agronomic characters are under trial to test their performance.

Though some of green gram mutations, especially the anthocyanin mutations approach very near to some of the cultivated varieties, they are, however not exactly identical. The induced mutations are, in general, more drastic than those which have evolved spontaneously and selected for cultivation.

Neutron irradiation gave a higher frequency of mutation than X-rays. The mutation rate was 19 and 24 per cent in 60,000 r (sublethal) when calculated on the basis of the number of segregating families per 100 R_1 plants and the number of mutation cases found per 100 R_1 plants respectively. In case of neutrons, it was 30 per cent at sublethal dose calculated on both ways.

However, the mutation spectrum was narrower following neutron treatment than in X-rays. The mutation spectrum was also different in the two different types of radiations. X-irradiation gave a higher frequency of chlorophyll and anthocyanin mutants and less morphological mutants. In neutron irradiation, on the other hand, a higher frequency of morphological and lower number of chlorophyll mutations were obtained.

It was observed that though 60,000 r produced higher rate of mutation, the same types of mutations were recovered in both the doses. Hence, 30,000 r which is much lower than the sublethal dose may be suggested as the optimal dose for mutation breeding. Application of lower dose would eliminate drastic effects present at the higher dose.

Most of the mutants were controlled by single recessive genes. Some of mutations were caused by chromosomal aberrations associated with meiotic irregularities in the PMC's. In two mutants, present of one or two extra chromosomes were detected. Pleiotropic effect of the gene was observed in several mutants. In one case, the mutant gene had incomplete penetrance.

6. P. N. BHADURI (Burdwan) : *Mutation studies in rice.*

X-ray induced mutations were isolated and studied by exposing both dry and wet seeds as well as dissected embryos both mature and immature till X_4 generation.

For this study several recommended varieties of rice by the State Agriculture Department were used including a Javanese variety Kerangserang. X-ray doses from 10,000 r to 70,000 r were employed for whole seeds whereas for dissected embryos the dose varied from 10,000 r to 35,000 r.

The wide range of mutations that were isolated have been broadly grouped as follows :—

- (1) Agronomically superior showing potentialities for establishing as an improved variety.
- (2) Variants which may be used for further exploitation in the rice breeding programme.
- (3) Chlorophyll mutations.
- (4) Morphological mutations.

The mutation spectra obtained from dissected embryos have been compared with that of whole seeds. As irradiated embryos were grown in culture media, a higher percentage of vital mutations could be raised. A mutation of "*ashkhata*" showing higher yield potentialities and grain characters is now under trial in X_4 generation.

From the X-ray irradiated whole seeds, the variety "*satika*" not only gave the maximum number of mutations but also produced a wide range morphological variations with respect to their habit, panicle and grain characters. Of special interest are the 'Dwarf mutations' with broad, erect leaf; deep green colour and compact panicles

obtained from both NC-1626 and 'satika'. The medium height mutation of NC-1626 with broad erect leaf and compact wheat like 'anicle' is showing most of the promising characters of an agronomically improved and superior variety. A few mutations from the photoinsensitive varieties are showing photosensitivity.

The varieties chosen from the 'aman' (photosensitive) group of rices appeared less responsive to irradiation. A marked difference with respect to relative responses to X-rays by different varieties have been established. This was particularly evident when dissected embryos were exposed to irradiation.

- ✓ 7. H. K. JAIN, R. N. RAUT, Y. G. KHAMANKAR and S. K. NERWAL (New Delhi) : *Some basic and applied considerations in relation to induced mutations.*

Studies will be described which are of interest from the point of view of mutation rates of genes. The specific locus method has been followed in *Lycopersicon* for analysing the effect of a number of chemicals which are known to attack particular bases of the DNA molecule. It has been found that a number of gene loci are particularly sensitive to the action of one or the other of these mutagens which have not been tested earlier on higher organisms. The implication of these findings for the chemical structure of the affected loci will be discussed. Also, the effects of chemical mutagens will be compared with those of X- and Gamma rays and in this context some radiation induced variation of practical value will be described.

- ✓ 8. PREM P. JAUHR (New Delhi) : *Induced mutations in relation to potato improvement.*

In India potato improvement work has been in progress for considerable time and Pal and Pushkarnath (1951) found that crosses between the *desi* and the best commercial varieties from Europe and North America did not prove to be of much practical utility as the semi-wild characters of the *desi* types were dominant and hence the scope of selection of desirable types limited. To overcome this obstacle induced mutagenesis can be a fruitful approach. To employ this potent tool for the improvement of potato the present studies were started in this Division in 1963. Some commercially-important varieties, viz., Kufri Red, Kufri Sindhuri, Kufri Neela and Up-to-date were taken up for the present work. The mutagens used were : (i) Gamma rays, 6 Kr and 10 Kr, (ii) UV radiation plus gamma rays, 6 Kr and 10 Kr, (iii) Radio-active isotopes, P^{32} , S^{35} and Ca^{45} @ 150 μ c/tuber or sproutling. Some results obtained during these investigations are reported in this paper.

A wide range of somatic aberrants was observed in the VM_1 and subsequent generations. The different mutants included those in the shape of leaves and shape and colour of tubers. Two important mutants for colour in the Kufri Red and Kufri Sindhuri varieties were the white tuber mutants which seem to be desirable characters for these commercial varieties. These white tuber mutants with somewhat shallow eyes were induced by the use of gamma rays alone and in combination with UV radiation, and are now being multiplied. The practical utility of the results achieved will be discussed.

From these preliminary observations, it would appear that induced mutations can open up several possibilities for potato improvement.

9. N. M. NAYER (Simla): *Problems of mutation breeding in vegetatively propagated plants.*

Vegetatively propagated plants would appear to be ideally suited for improving through mutation breeding because many of their improved cultuars had their origin as 'sports', and any improvement effected could be immediately propagated asexually. There is also the need to use this method where sexual reproduction has degenerated and it is consequently not possible to employ conventional breeding methods. Yet, a review of work would show that only limited success has been achieved using this method. The difficulties encountered in utilizing induced mutagenesis in improving vegetatively propagated plants are analysed and methods suggested to overcome them.

The importance of time of mutagenic treatment in relation to the mode of histogenetic development of the species and need for varying handling methods of progeny populations accordingly are not properly appreciated. Handling methods would also have to be varied depending upon whether propagating organ and economic part are same or not. Intrasonic selection is another limiting factor. Low thresholds of tolerated doses result in low induced mutation frequency. High incidence of polyploidy and chimeral nature, long juvenile phase, life cycle and perennial nature of many of them, poor understanding of their genetics, bulky nature of propagating organs, high prevalence of viral diseases, which produced syndromes of mutagenic effects and difficulties of raising sufficiently large populations in perennial plants are some of the other problems. Neutron irradiation is thought to be efficient with vegetatively propagated polyploid organisms, but irradiation facilities are few and expensive. Chemical mutagens have been of only limited effectiveness.

While problems are many, they are not insurmountable. Improvements are often desired for a single character only, and these can be effected often by modifying the chimeral nature. Methods are also suggested to overcome the problems enumerated above.

To Dr. Swaminathan
Bangalore
10.1.67

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ADVANCE NOTES ON SYMPOSIA & DISCUSSIONS

SECTION OF BOTANY

President : PROF. R. N. TANDON, PH.D. (LOND.), D.I.C., F.N.A.Sc.,
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I. "REORIENTATION OF BOTANICAL TEACHING AND RESEARCH FOR NATIONAL PROSPERITY"

1. R. MISRA (Varanasi) : *Ecology*.

The eight year International Biological Programme (IBP) launched by the International Council of Scientific Unions (ICSU) is oriented around ecology and it emphasizes education and research in the subject. The overall integrating character of Ecology in the various fields of biology and physical sciences and the biological basis of productivity in relation to human welfare, which incidentally is the title of the programme, need no further emphasis on the relevance and urgency of reorienting our teaching and research in ecology.

A perusal of the syllabi of various University Courses in botany and examination papers shows that with a few exceptions, they still maintain the rigidity of considering ecology as static and descriptive anatomy of plants in relation to moisture or some other environmental factors. It is little realised that the definition of the subject has undergone in recent years, drastic transformations so as to base it on flow of energy and cycling of minerals within the ecosystem. But how can this be appreciated when the very purpose of field studies in the Universities is defeated by relegating then to mere collection of materials for laboratory work? A scrutiny of the so called field books of students of different Universities has indeed shown that a great deal of time is spent in railway trains, buses, towns, botanical gardens and laboratories during the tours without learning any thing about our natural heritage. They have no opportunity to realise that man is a part of the various ecosystems which he is always upsetting and most often to detrimental limit. But this can be learnt and practiced to advantage by the study of ecology in its proper perspective.

The concept of ecology has evolved through—first a qualitative and then a quantitative approach. It is a complex science connecting a variety of disciplines. Even so it is high time for us to realise the value of ecology in economic development of the country and give it a more important place in the educational curricula right from the study of nature in the school to the post-graduate and research levels. Julian Huxley (1962, Endeavour) has laid sufficient emphasis on this problem.

Any suggestion on a balanced course in ecology has to take into account the principles and bases of the subject on a dynamic pattern and their interplay in maintaining ecosystems, biosphere and biological productivity. The study has to be

oriented towards the conservation of natural resources and the place of man in nature. Since botanists have to deal primarily with the producer systems, their responsibility is great as teacher and educators. Attention is drawn to a report of a UNESCO Committee of experts who met in Tunisia in June, 1964 for recommending University courses on ecology to students of botany.

Given a suitable syllabus, the university teachers can do adequate justice to it by discussing the methods of implementation in Summer Schools. One such school sponsored by the U.G.C. in Varanasi has cleared many points of differences and difficulties. Active participation of the students on lines of investigation, or problem raising and problem solving approach is the only way of education and this has to be achieved in the field, class room, laboratory, seminar and every where. Research problems both in the fields of autecology and synecology should include data on population ecology and productivity.

2. M. S. SWAMINATHAN (New Delhi) : *Cytogenetics and Plant Breeding.*

A revolution has taken place in the recent years on the concept of yield in crop plants, thanks to developments in cytogenetics and plant breeding. The exploitation of heterosis as well as the alteration of the morphological frame of plants in a direction that would increase the efficiency of utilization of solar energy and chemical nutrition have opened up new vistas in crop production. Genetic engineering has not only enabled the increase of the production potential of crop plants in a quantitative sense but has also helped in altering the aminoacid balance of proteins in plants like maize and wheat. Thus, these sciences are of great importance to our country since the most serious problem facing us is the inadequacy of our agricultural output. In order to achieve worthwhile results in cytogenetics and plant breeding research, the students need to be enabled to develop a deep understanding of plants and their environments. The contrasting requirements of natural and human selections should be clearly understood and the student should be taught to see for himself how far the phenotype betrays the previous selection history of the plants. The realisation that plant breeding is merely applied gene ecology has to be brought home so that there would be an adequate appreciation of the interaction between the genotype and the environment. To achieve these ends there has to be a reorientation of teaching plant morphology, anatomy, geography and ecology, besides cytology and genetics.

3. R. N. SINGH (Varanasi) : *Place of Microbiology in Teaching and Research in Botanical Curricula of Indian Universities.*

The teaching and research of Microbiology in botanical curricula of Indian Universities is sadly neglected. There is often a paper at the M.Sc. degree course devoted to 'Algae, Fungi, Lichens, Bacteria, Viruses, and Plant Pathology', which is generally bogged with morphological and taxonomic details. Bacteria and viruses are treated mainly as causal agents of plant diseases rather than cells and organisms. The major "breakthroughs" in biology during the last two decades have stemmed from the study of microorganisms. In fact our basic understanding of life processes and the vex problem of the origin of life, to the extent to which we know them now, has been possible only through microbial world. Our present knowledge of the fine structure and function of the gene, the prime mover of life, has been possible only through the study of microbial and biochemical genetics. DNA as the carrier of genetic

information gained validity with Avery, Macleod and McCarty's studies on pneumococcal transformation and Hershey and Chase's demonstration that DNA is the infective component in bacterial viruses. The distillation of biological thought "one gene-one enzyme" now "one cistron-one polypeptide" by Beadle and Tatum came out from the study of microorganisms.

It is very well said by Tatum that we are in "The Age of DNA". The RNA viruses present a challenge to biologists and biochemists. The very biosynthesis of DNA and RNA *in vitro* by Arthur Kornberg and Severo Ochoa has been possible by enzyme systems extracted from *Escherichia coli* and *Azotobacter vinelandii*, respectively. The *in vitro* biosynthesis of proteins by Nirenberg and Matthaei and their recognition of the genetic code has been realized from the study of the microbial systems. The induction and repression of enzyme systems and the concept of regulation and operon mechanism was developed by Lwoff, Jacob and Monod from the study of microorganisms. Our present understanding of the basic life processes of photosynthesis and biological nitrogen fixation has been possible by the study of microbial systems. Thus, there has been a revolution in biology which is "The Revolution of Molecular Biology", and has its origin in Microbiology.

The science of botany today is not the same science of fifty, twenty-five or even ten years ago. Today's accelerated pace of research aided by new instruments, techniques, and points of view, imparts to Botany a rapidly changing character as discoveries pile one on top of the other. All of us are aware, however, that each new and important discovery is not just a mere addition to our knowledge, it also throws our established beliefs into question, and forces us constantly to reappraise and often to reshape the foundations. An adequate presentation of the dynamic state of the subject is, therefore, a formidable task and a challenge worthy of universal recognition. Our syllabi are outdated and considerable pruning of descriptive morphological and taxonomic details have to be required in order to bring in new material. The concept of Prokaryota and Eucaryota is a revelation. To quote Stebbins (1964), "To even the best human biologists they are in many ways separate worlds, which must be studied separately." The bacteria and blue-green algae belong to the Prokaryota, still the latter are treated with the rest of the algae from which they are far removed. It is strongly suggested that they should be treated together.

The present position of botanical teaching and research in Indian Universities lacks objectivity. It is far removed from the prime aim and need for study of plants. The truth that virtually all the food supply of the world originates in the photosynthetic process of the green plants and also that plants supply the power as fossil fuels in the form of coal, petroleum and natural gas derived from the same process, is often dulled by familiarity. The summary food relationship remains one of inescapable realities binding botanical science to the communities of men. This truth is even lost sight off by those students and teachers who profess Botany in their quest for narrow specialization. Botany is rarely exposed in its broader aspects and perspective in relation to the problems and needs of the community. In these days of acute food shortage it is suggested that the natural resources of the country should be tapped for unconventional methods of food production such as microbial food.

A distinction is sometimes made between fundamental and applied science. There is no doubt that a sound and broadbased science is necessary for its application but the aims and objectives of the science should not be lost in narrow specialization. It is proposed to discuss a case-history in botanical research, i.e., the work on the blue-green algae by the author. What could be more appropriate than this to show

the relationship between fundamental and applied research and for realization of the objectivity of botanical research in relation to national prosperity, which need hardly be emphasized at the moment in our country.

4. B. M. JOHRI (Delhi) : *Experimental Embryology.*

The teaching of embryology is usually limited to a description of developmental stages most of which are demonstrated from prepared slides. The students seldom get a chance to study the germination of pollen, or trace the developmental sequence of endosperm and embryo by dissections and preparing whole mounts.

In recent years a more dynamic approach has been followed in research and teaching. As a part of laboratory exercise a student could study (a) correlation between the size of the flower bud and the structural changes in development; (b) stages at anthesis; (c) time relation between pollination and fertilization, and development of endosperm, embryo, seed and fruit; (d) and possible reasons for sterility in seeds. This can be further extended to investigating the barriers to crossability by use of stored viable pollen, manipulation of artificial pollination techniques, and ensuring proper development of seed by *in vitro* culture techniques. It has already been demonstrated that the knowledge of embryology, especially of crop plants, has immense applications in plant breeding programmes with direct bearing on food production.

Some of the simpler techniques mentioned above should be practiced at the B.Sc. level, and others by M.Sc. students. Developmental embryology is a basic discipline and, besides applications in plant breeding, it provides useful data for phylogenetic considerations as well as a study of evolution of higher plants. India commands a leading international position in angiosperm embryology; we should not only maintain this high tradition but make every effort to improve it further.

5. K. S. BILGRAMI (Jodhpur) : *Plant Pathology.*

The present literature in Plant Pathology is about four times greater than what it was some forty years ago. This rate of production will be higher in the coming years. Therefore, extreme caution is required for selecting the published scientific facts to be taught to students. A careful pruning of comparatively out-dated material is a constant need. It is needless to emphasize that proper application of plant pathology can be of immense value in the agricultural programmes of any country.

Initial efforts in Plant Pathology were mainly directed towards the survey of various types of diseases, symptomatology, factors responsible for the perpetuation of the disease and certain control measures. During the last two decades several problems of fundamental nature like the role of vivotoxins, enzymes, soil micro-organisms and biochemical nature and nutritional response of the pathogenic organisms as well as their mode of transmission have been extensively studied.

It is unfortunate that despite these advances there has been no basic change in the subject matter presently imparted to the university students. The gulf between post-graduate teaching and the basic requirements for research is becoming wider. Due to routine and uninspiring teaching, the students develop no special appreciation for the subject at the Master's level. Most syllabi lay special emphasis on the "Fungal diseases of crop plants of a particular region". Such an approach has a very misleading impact on the students who regard Plant Pathology to be only slightly modified

Mycology. Much of the failing is simply because we want to raise the structure on a single pillar i.e., Mycology.

Improvement is possible if instead of teaching specific fungal diseases, greater attention is devoted to the general behaviour of plant pathogenic organisms including fungi, bacteria, viruses and nematodes. Elementary knowledge of plant biochemistry has now become indispensable for the students of Plant Pathology. The importance of fundamental principles requires to be impressed further. More stress should be given to the factors responsible for the availability and viability of the inoculum, importance of vectors, influence of environment on disease rate, role of different enzymes at various phases of infection, role of vivotoxins, morphological and physiological changes induced in the host, effect of nutritional imbalance on plant growth, mode of fungicidal action, biological control with special reference to soil-organisms and hyperparasites.

For practical exercises a laboratory cum field centred course will be more meaningful as we cannot neglect them either. Presently old, preserved and unfamiliar materials are given to students for study. We are thus producing section cutters and technicians but not students who can do investigations. The time wasted in preparations should be saved and channelized for productive work. Examining permanent slides or merely scraping or teasing, the material would do. It would certainly be more exciting if students learn the technique of isolating and culturing the pathogenic organisms and study the factors influencing their growth.

A close co-ordination between laboratory and extension programmes is important. It would be appropriate if students undertake a fortnightly survey of fields or gardens and make systematic and chronological field notes. A few simple field experiments can be designed to test the pathogenicity of the organisms and to determine their host range. Variations in symptomatology of different susceptible hosts and the influence of environmental factors on pathogenicity will be fascinating for the students of M.Sc. class.

6. H. Y. MOHAN RAM (Delhi) : *Economic Botany.*

In the days of synthetics, space travel and molecular biology, the plea for the introduction or reorientation of a course in economic botany may seem unsound. In fact, in many Universities this subject does not feature in the botany syllabus.

Critics can dismiss economic botany as a subject without a general philosophy or as a discipline which does not lend itself to experimentation and creativity. Instead of attempting to defend this subject with a sense of hopelessness, it is useful to analyse its importance objectively.

Despite the tremendous advances made in technology, man is inescapably a part of the living world and still awaits the harvesting of annual crops for his sustenance. Recent biological achievements are indeed great. While effort should be made to modernise our courses, the young and developing minds at Universities must be exposed to the great discoveries of the past like the vast economic potential of the angiosperm seed; agriculture; origin, introduction and domestication of economic plants; the historical and social influences of crops and such other topics. Besides enlightening, these accounts will help the students develop a proportionate, mature and sound appreciation of plant life and Nature around them.

Economic botany has ceased to be mere story telling. It is a subject which brings together work done in various branches of science together. In this sense it is

as much a body of experimental knowledge as other branches of botany. Plant utilisation research, if you may call practical economic botany may be called is progressing at a great speed for the general improvement of living standards.

If the subject is being taught presently without relevance to our every day problems, it is serving no particular purpose. In fact, this aspect of botany is the closest to man's existence. Every student of biology and indeed every educated person must therefore, know some basic facts about our food problem, existing plant resources—introduced as well as indigenous, aspects of crop improvement, export of raw materials of plant origin, etc.

In addition to providing a better background for future planners, this education will undoubtedly enrich the life of the student in what ever profession he may eventually find himself.

7. T. S. MAHABALE (Poona) : *Curricula and General Considerations.*

The present day curricula in Botany at all levels are loaded with theoretical courses rather than practical. In view of nation's needs, they need reorientation more in the direction of applied side. Whereas the school courses should have emphasis on observation and information in the college courses, especially at the graduate level, should lay more emphasis on applied botany and not on pure fundamental courses. It is possible to achieve this especially at post-graduate level by combining courses in Taxonomy with forestry, Agriculture and Geobotany, Physiology with Bacteriology and Antibiotic production, Mycology with Plant Pathology, Economic botany with Plant Chemistry, Palaeobotany with geology of coal and oil, Palynology with Medical and Bee palynology, Plant anatomy with wood preservation and paper pulp industry and Genetics with plant breeding, etc.

The paper discusses how this could be achieved. Should our curricula change accordingly they would widen the outlook of our graduates and increase their utility to meet the nation's needs.

8. J. J. CHINYOY (Ahmedabad) : *Teaching and Research in Biology—The Urgent Needs of Free India.*

Our system of teaching science is manifestly defective. It is the experience of all those who are engaged in the training of young minds that even at the post-graduate level our students are innocent of the fundamentals of science. This defect originates in the school and is carried to the college and eventually to the University. This defect is unfortunately on the increase.

Of all the sciences, biology is the most neglected in India. Unless this deficiency is met by a concerted and a planned effort we cannot tread the path of scientific progress which is the imperative necessity of our country bogged down for centuries.

A few changes necessary for the improvement of teaching and research in Biology are :

(1) Teaching of biology should start from the seventh class onwards. There should be a dynamic rather than a static approach in the teaching of biology. Emphasis should be laid on laboratory and field work. In fact theory should be woven round observations and experiments.

The curriculum should include a broader knowledge of chemistry, mathematics, physics and statistics from the seventh class onwards. This is an immutable must for moulding a modern biologist.

(2) The course at the graduate level in the University should be truly biological and not a hotch-potch of some zoological and botanical topics compounded together.

Many modern biochemical, physiological and genetical aspects of plants and animals have much in common and can form a part of the above mentioned curriculum of biology.

At the post-graduate (M.Sc.) level there should be greater emphasis on applied aspects or zoology, with training in modern methods of research.

(3) Exigency of time demands that research work in the University should be planned and that fundamental and applied research work on problems of national importance be undertaken.

(4) There is an imperative need for a radical reorientation of our present system of evaluation which is based upon the mistrust of the teacher and the student alike.

(5) Our Union Government in collaboration with State Governments should convene a conference of teachers of schools, colleges, universities and other bodies of higher learning, with a sprinkling of administrators, to deliberate upon the entire problem of science teaching at all levels. This body should formulate an integrated course of learning in biology and other sciences at all levels; and work out a system of evaluation commensurate with the principles of pedagogics, and without the element of mistrust of the teacher and the student, on the model of advanced countries.

9. U. N. CHATTERJI (Jodhpur) : *Plea for an Eco-Physiological Approach.*

Syllabi in the Indian Universities fall short of fundamental necessities in relation to botanical teaching and research. I would like to draw particular attention to the teaching and research in eco-physiology. Universities usually have in their syllabi a full paper on plant physiology. Ecology has been much undermined and it is bracketted with plant physiology as a subsidiary subject. We cannot ignore the importance of environmental conditions in biology or botany. The little eco-physiology which is taught solely concerns the angiosperms without reference to cryptogams.

The post-graduate students are excessively busy study dead materials and it is only in plant physiology classes that they handle living specimens. Because of their greater familiarity with the dead stuff they are bewildered to study living plants.

The teaching courses in physiology are based on contents of standard books imported from U.K. and U.S.A. Consequently the plant materials dealt therein are not familiar to our students. There is thus a compelling necessity of having scientific data on local plants. This helps students particularly when they undertake post-graduate research. Even a student well versed in the fundamentals fails to apply his knowledge to a particular problem in ecology. This is due to lack of sufficient training at the graduate level in the composite discipline of eco-physiology.

The students trained in the classical "Hydrophytes and Xerophytes approach" to ecology fail to assess the totality of variable factors in a plant population.

The large scale exploitation of radioactive materials has polluted the atmosphere, land and waters. Research should be done on the effects of radiation on life.

Charting out mechanically the vegetation in the field without correlating the data with those in the laboratory has no meaning. Many Universities consider Botanical excursions as unimportant. A few which encourage them do not have trained teachers to call attention to the variations in plants due to eco-physiological complexities arising in different localities.

10. K. B. DESHPANDE (Aurangabad) : *Some additional thoughts on teaching and research in Plant Pathology.*

Plant pathology is as much a field science as it is a laboratory science. To develop it as an effective field subject a farm or a botanic garden has to be attached to the University in which students could be taught various field techniques including plant breeding. This will enable them to study :

(1) the establishment of pathogenecity, (2) artificial induction of epidemics, (3) aerobiological aspects of time and circumstances under which incidence of disease occurs, and (4) forecasting the incidence and developing control measures.

Subjects like nematology and entomology should be taught by the professional zoologists. Botanists and Zoologists should closer come and develop border line subjects for mutual benefit. Meteorology or agro-climatology and biometry are other essential subjects which must be taught if we want plant pathology to develop on proper lines.

The duration of the M.Sc. course is an important issue. In view of the shortcomings of teaching of science in undergraduate classes and the vast expansion of knowledge of every branch of science, we have to consider extending the M.Sc. course to three years or to have two years of pre-degree or P.U.C. course with five years of undergraduate studies in addition to improving the methods of teaching.

II. "SOILS AND SOIL ORGANISM"

1. K. G. MUKHERJI (Delhi) : *Ecological studies on the micro-organic population of usar soils.*

Soil is a universal natural culture medium supporting an abundant and extremely diverse population of micro-organisms. Soil is constantly changing with the change of environment and, consequently, its micro-organic population is controlled by various factors such as edaphic (soil-type, soil-profile, soil-moisture and soil-reaction), seasonal (temperature, rainfall and light), and ground vegetation.

Considerable work has been done on the effect of some of the above factors on the micro-organic population of the soil, but most of it deals with acid or normal soils both cultivated and uncultivated. Very little is known about the alkaline soils, and, therefore, investigations were undertaken on the effect of soil-pH, seasonal changes, and soil-depth on the distribution of micro-organisms of usar soils. Soils with pH 7.1 to 11.0 were randomly selected (from various localities at Lucknow, Kanpur, Hardoi and Rai Bareilly) and the results are summarised below.

The upper horizon of soil showed the maximum number of micro-organisms, but there was almost no correlation between the average number of bacteria per gram of soil and the soil-pH. On the other hand, the fungi showed a progressive decrease in number from pH 7.1 to 10.8, beyond which they were absent. The number of fungi increased during rains, and that of the bacteria during winter.

A large number (123) of fungi were isolated, and their frequency percentage varied during different months of the year. *Aspergillus* was the most dominating form. The relative percentage of species of each class of fungi occurring in these soils was : Zygomycetes 15 per cent, Ascomycetes 15 per cent, and Deuteromycetes 70 per cent.

During the course of these investigations (1957-1961) one new genus and six new species were identified; 27 species have been reported for the first time from India.

The new genus, *Achaetomium*, belongs to a new order Achaetomiales under Ascomycetes. Three species of this genus have been described and while one (*A. strumarium*) was isolated from user soils, two (*A. globosum* and *A. luteum*) were from fertile soils. Five other species isolated from user soils are: [*Helicostylum lucknowense* (Mucorales-Thamndiaceae); *Tripterospora tetraspora* (Plectascales-Tripterosporaceae); *Chaetomium fusisporale* (Chaetomiales-Chaetomiaceae); *Aspergillus striatus* (Moniliales-Aspergillaceae) and *Sporotichum carthusio-viride* (Moniliales, Moniliaceae).

The major population of fungi was the same as that in fertile soils, but their order of dominance varied with the pH of the soil. A few of these forms have not been recorded previously from either normal or acid soils (both cultivated and uncultivated) suggesting their preference for alkalinity.

2. R. N. SINGH (Varanasi): *A reappraisal of concept of soil algae.*

Algae growing on or near the surface of soil are considered to be soil algae. Two communities are generally recognized: the surface community and the subterranean community. In the present state of knowledge, the latter appears to be redundant. Although some algae and algal propagules are likely to be washed down the surface of soil with percolating rain water they are not likely to be active in view of their obligately phototrophic nature. In laboratory cultures some soil algae have been found to be capable of heterotrophic growth and their number is increasing but, up till now, only slow growth has been demonstrated within the soil while there is abundant evidence for very active growth in the upper few millimetres where light may be sufficient for photosynthesis. Following the pioneer work of Bristol-Roach and more recently the concept of 'rhizosphere' in connection with the study of soil fungi there is a growing tendency to investigate algae from different depths of soil. This again is an erroneous concept.

Soil algae grow best on moist soil surface. Waterlogging produces semiaquatic conditions and communities; hence the use of liquid enrichment cultures may give a wholly false impression of the quantitative composition of the soil flora. Such enrichment cultures also give exaggerated picture of some insignificant forms of algae or suppress others which are dominant forms in natural growths. Therefore, the correlation between direct examination and cultures, laboratory and field conditions, is uncertain. The laboratory methods should simulate natural conditions and soil moist cultures are most applicable.

It is thus the surface community which is all important. The algae on the soil surface which can resist severe and prolonged drought, high temperature, alkalinity and salinity, are the 'true' soil algae. The basic problems of sampling and quantitative estimates lack adequate solution.

The relationship of soil algae with other soil organisms and macrovegetation is less clearly understood. Although the algae in general provide a more suitable environment for the germination of seeds of higher plants, aeration of their roots, direct casual and beneficial relationships are so far established only in case of rice crop. Some algae live symbiotically in the roots of higher plants. Chemical substances secreted by algae are beneficially utilized by bacteria and fungi. However, some of them are likely to be antibacterial and antifungal. In view of the recent finding of a

blue-green algal virus there is possibility of the role of phycophage in soil algal flora.

Soil algae are often abundant in arid, eroded and virgin soils and change their physical and chemical structure by helping to conserve moisture and by adding organic matter. In alkaline and saline soils the massive growth of algae cause considerable changes in the balance of soil pH, Na/Ca ratio in the base complex, iron and aluminium. They also help in the flocculation of soil colloids. In recent years the most important role of soil algae has been realized in the maintenance of soil fertility through their nitrogen fixing ability and in the reclamation of alkaline lands.

3. R. MISRA (Varanasi) : *Energy and mineral relations of the soil-complex.*

The soil is considered a complex of (a) the mineral particle system, (b) the organic particle system, (c) the solution or water-salt system, (d) the gaseous or air system, and (e) the system of organisms or their parts. All the named systems are highly interacting and dynamic. Only such a complex can provide water and nutrients to, and hold the roots of, plants growing thereon.

It is perhaps more profitable to view the soil in terms of energy flow and mineral cycling.

The solar radiations received on the soil surface are largely dissipated *via* heat energy, leaving the effect of temperature variations therein. But the green plants entrap light energy, convert it into potential energy in the form of organic compounds and cause growth of roots within the soil. The litter of dead organic materials add energy to the soil in the same manner. The entrapped energy is thereafter, made to flow gradually through the bodies of parasites and saprophytes in which process energy is being lost at each of the conversion levels. The rate of addition, decomposition and re-use of dead organic material in all soil becomes a function of temperature, moisture, aeration and chemical nature of the organic compounds. At lower temperatures and with poor aeration the ratio of dead organic matter content to the living biomass is high as in peat deposits and it is reversed under warmer and aerated conditions as in our tropical soils. The variety of soil organisms *vs* their populations or species : individual ratio or species diversity is always high with the kind of carbohydrates, fats, proteins and other compounds, not excluding antibiotics, present in the soil because of food specificity of the organisms. The microorganisms are far more important in the soil environment as despite their insignificant individual size their biomass may far exceed that of all the larger organisms and living roots put together. Cragg (1961) has indeed estimated that this biomass per unit area over a large piece of moorland in U.K. far exceeds the mass of all the sheep grazing over the turf. In the ecological diversity maintained within the soil the scheme of nature is clearly to ensure that energy flows through rills and trickles, and is not allowed to run to waste in floods and bonfires.

The cycling of minerals within the soil mass is equally important phenomenon. The nutrients absorbed by the plants are returned to the soil and reused. Thus the resources are renewable provided conditions are favourable for fixation of sufficient energy. The soil structure, the colloids and exchange complexes and the entire dynamic behaviour so necessary for fertility are all maintained by the green plants. The conservation of the nutrients is thus made possible by continuous but slow releases and uptakes by myriads of organisms.

It is concluded that soil conservation requires a good knowledge of the ecology of soils and soil organisms. The paper is illustrated with lantern slides.

4. K. B. DESHPANDE and USHA CHAPALGAONKER (Marathwada) : *On the study of germination of soil fungi.*

While fungi from soils of Marathwada were studied, a number of species of *Aspergilli* were isolated. Out of them five species i.e., *A. niger*, *A. flavus*, *A. terricola*, *A. sulphureus* and *A. nidulans* were used to study germination of their spores in distilled water, autoclaved and nonautoclaved soil extracts, culture filtrates of *Helminthosporium appatarnae* and in solutions of different constituents of two synthetic media (pectin peptone and glucose nitrate medium) using them in the same concentrations.

Results of germination for 60 hours in different media indicate that *A. niger* and other species either do not germinate in distilled water or germination ranges from 1-2%. From this it is clear that spores of these soil-borne fungi require a stimulus for germination as has been reported earlier by Brown (1936) and by Wilcoxon and McCallan (1934) for conidia of *Penicillium* and other fungi.

When they were germinated in drops of soil extract, again *A. niger* did not show any germination and other species except *A. sulphureus* germinated in the range from 1 to 5 per cent. This can be considered as a fungistatic effect of the soils indicating a deficiency in nutrients of the soil capable of supporting fungal spore germination.

When these species were germinated in 1% glucose, 0.1% MgSO₄, 0.25% peptone, *A. niger* did not germinate at all indicating that these chemicals do not stimulate germination. It showed 20% germination in 0.1% KH₂PO₄ solution. *A. niger* again did not germinate in a 8-day old culture filtrate of soil-borne *H. appatarnae* which was cultivated on glucose nitrate medium.

In 1% pectin solution and in 2-day old culture filtrate of *H. appatarnae*, *A. niger* showed 40% and 100% germination respectively. From this it is clear that pectin or intermediate products of its hydrolysis supply some nutrients for *A. niger* to germinate.

It is clear from these results that spores of some soil-borne fungi require a stimulus for germination and which can be supplied by pectin or its hydrolytic products. This stimulus also may be supplied by other soil-borne fungi like *H. appatarnae* growing together with *A. niger* in soil and it may be cited as an example of synergistic relationship between microorganisms in soils.

5. R. Y. ROY and R. S. DWIVEDI (Varanasi) : *The behaviour of fungi in soil.*

This paper deals with different aspects of fungi inhabiting soil viz., (i) behaviour of fungi in rhizosphere, (ii) behaviour of rhizosphere fungi in response to foliar spray of hormones, and (iii) soil fungistasis and behaviour of fungal spores.

The work in this laboratory by Dwivedi (1959) on soil fungi from near root systems of some grasses has shown that certain fungi were associated with the root system of particular grass association and that in some cases their number was qualitatively high which is attributed to the possible role of some organic nutritive substances secreted by roots. Further work on rhizosphere mycoflora of cultivated legumes viz., *Lens esculenta* and *Cicer arietinum* (Gujrati, 1965), wild legumes viz., *Cassia tora* and *Crotalaria medicaginea* (Sullia, 1966) and fodder grasses viz., *Dichanthium annulatum*, *Setaria glauca* and *Bothriochloa pertusa* (Leelavathy, 1966) has shown that colonization of fungi in rhizosphere is greater than in non-rhizosphere which is attributed to the presence of amino acids, viz., Leucine, Methionine, Alanine, Glutamic acid, Aspartic acid, Asparagine, Cystine, Phenyl alanine, Arginine, and sugars such

as fructose, glucose, lactose, sucrose, raffinose, rhamnose, and arabinose in root extracts and exudates.

Behaviour of fungi in the rhizosphere in response to foliar spray of hormones viz., Indoleacetic acid (IAA), Indole 3-yl propionic acid, 1-naphtha acetic acid and 2-naphthacetic acid has been studied and an increase in the mycopopulation was reported. Sullia (1966) showed the foliar spray of GA and IAA increased the mycoflora significantly. He found that the maximum number of fungi in the case of *Crotalaria medicaginea* was with 100 ppm dose of GA. In *Cassia tora* 50 ppm of GA was the most effective. In the case of fodder grasses there was no significant change in the mycopopulation.

The inhibition of fungal spores germination in unsterilized soil has been shown by several workers (Dobbs and Hinson, 1953; Hessayan, 1953; Jackson, 1958) which they attributed to the presence in soil of fungistatic character. The production of antibiotics in soil by micro-organisms adds to the soil an inhibitory effect on germination and survival of fungi. This property is overcome either by adding glucose or by presence of rhizosphere effect. The junior author found complete inhibition of conidia of *Helminthosporium sativum* and *Fusarium culmorum* on glass slides in unsterilized soil but when wheat seedlings were grown on slide majority of the conidia germinated. Whether soil contains a fungistatic activity that inhibits the germination of fungus spores has been questioned by Lingappa and Lockwood (1961). They consider that inhibition is due to growth of antibiotic-producing organisms on assay substrates used for the assessment of fungistasis. Lockwood (1964) further suggested that lack of nutrients may be important factor in the inhibition of spore germination.

The fungistasis is not due to stimulation of growth of micro-organisms on assay substrates is shown by Jackson (1964) who found that *Penicillium citrinum* spores on glass fibre filter paper on soil failed to germinate whereas, two-third of similar spores germinated on same substrate moistened with distilled water. Jackson and Dwivedi (unpublished data) found 100 per cent inhibition of spore germination in *Penicillium citrinum* and *Aspergillus niger* on glass fibre paper which was similar to that on agar blocks with 0.5 per cent peptone on soil.

6. R. Y. ROY and SHANKER BHAT SULLIA (Varanasi): *The influence of the rhizosphere mycoflora on plant growth.*

The study of the effect of rhizosphere fungi on the growth and well being of the plants is a promising field of research. Many workers in recent years have envisaged possibilities of improving plant growth and crop yield by modification of the rhizosphere microflora. The effect of rhizosphere fungi on seed germination and growth of plants has been studied by Humphreys-Jones and Waid (1963) but very little work on this aspect has been done on other plants, especially leguminous plants. During a detailed investigation of the rhizosphere mycoflora of wild leguminous plants by the junior author in the Botany Department, Banaras Hindu University, a study of the effect of certain rhizosphere fungi on the seed germination and root growth of leguminous plants viz., *Cassia tora* and *Crotalaria medicaginea* was undertaken. The effect of fungi on seed germination was studied by soaking the seeds in their culture filtrates. *Curvularia lunata* had no effect on seed germination. *Fusarium nivale*, *Trichoderma lignorum*, *Cunninghamella echinulata* and *Aspergillus niger* reduced the percentage germination of *C. tora* seeds. *A. niger* greatly reduced the percentage germination of *C. medicaginea* seeds whereas, *F. nivale*, *C. echinulata* and *T. lignorum* increased germination.

The effect of the above fungi on the root growth of seedlings was studied by growing the seedlings in plant nutrient agar in culture tubes and inoculating the test fungus. The root growth was quite normal and the plants looked quite healthy in sterile tubes but in those inoculated with fungi the root growth was retarded.

In pot cultures the root growth of *Cassia tora* was studied by adding the culture filtrates of the rhizosphere fungi. The root growth was inhibited by *Trichoderma lignorum*, *Fusarium nivale* and *Aspergillus niger*.

7. M. N. SARIN and D. C. UPRETY (New Delhi) : *Intraspecific host specificity and strain variation in Rhizobium trifolii*.

Studies were carried out to investigate intraspecific variation in symbiotic activity of *Rhizobium trifolii* as it would necessitate development of strains specific at varietal or even intravarietal level. Two chromosome groups of *Trifolium alexandrinum* i.e., diploid ($2n = 16$) and tetraploid ($2n = 32$) were employed in this series of investigations.

Rhizobium strains were isolated from diploid and tetraploid *Trifolium alexandrinum* and both the isolates were tested on their parent as well as other chromosome group. Testing of strains were carried out under controlled conditions and periodic observations on growth characters and nitrogen content of the plants were recorded.

Growth and nitrogen content of various parts of tetraploid plants was significantly better than that of diploids when they were inoculated with the isolate from tetraploids and conversely that of diploids was better than that of tetraploids when they were inoculated with the isolate from diploids. The differences in nitrogen content in both the cases were because of nitrogen fixing capacity as well as the number of nodules.

The present findings thus clearly indicated that in *Rhizobium trifolii* there is a strain specificity even at the intraspecific level.

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FIFTY-FOURTH INDIAN SCIENCE CONGRESS,

HYDERABAD, 1967

SECTION OF AGRICULTURAL SCIENCES

President :—B. N. SAHU, B.Ag. (Nag.), M.S.A. (Toronto),
Ph.D. (Michigan State)

PRESIDENTIAL ADDRESS

OPPORTUNITIES FOR AGRICULTURAL SCIENTISTS TO FREE INDIA FROM HUNGER.

Mr. Chairman, distinguished scientists from abroad and India and friends.

I have great pleasure in welcoming you to the deliberations of Agricultural Sciences sections. At the outset, please allow me to express my deep appreciation of the honour that you have done me by electing me President of the Agricultural Sciences section of the 54th session of the Indian Science Congress and given me this unique opportunity of placing before you the solution of problem of food production as seen by an Agronomist.

Farmer in a developed country :—A visit to the developed countries impresses us with the good life in the country side. A farmer has enough food to be healthy, a decent house well electrified to live in, good clothes to wear, an automobile for easy movement, a radio for keeping in touch with the world and opportunities to share the privileges and duties of a citizen in a democracy. He has, also, a few Journals paying much more attention to farm life to spend his leisure time and to be acquainted with what is new in farming. Such tremendous achievements have been attained as a result of applying science and technical measures for increasing production. A modern society, therefore, can only be built on the foundations of science and technology.

A farmer in India :—A look to Indian Agriculture reveals that farming is practised for over fifty centuries. The farmer lives a quiet, routine life. He is bound by traditional agriculture. A country dependent on traditional agriculture is inevitably poor, There is indifferent food, bad clothing, lack of cultural and welfare services. Small and scattered villages lacking good communications carry on traditional occupation. The educated people do not like to live in villages and migrate to town. There is no romantic attachment to the rural areas and no educated urban dweller retires to the rural side in quest of peace. The rural communities, therefore, live in a world of their own. There are, however, some progressive farmers who know how to use what science says about soil, plant and animal and produce an abundance of food. But the capacities of the majority of farmers to absorb science, technology and innovations are limited. As a result, the level of production does not meet the requirements of growing population and a good expanding life.

Appraisal of efforts made to transform traditional agriculture :—The development of agriculture in India began in the sixties and seventies of

nineteenth century. Proposal for special Department of Agriculture originated with the Commission appointed after the great famine in Orissa in 1866. Research in agriculture started with the visit of Dr. J. A. Voelcker, Consultant Chemist in 1889. The Imperial Agricultural Research Institute was established at Pusa, North Bihar in 1905. Experiments at Pusa Institute produced some notable results. But these findings had little effect on Indian agriculture. Food production persisted in a virtual state of stagnation. The progress till 1928 can better be described in the remarks made by the Royal Commission on Agriculture appointed by Government of India, "In a country with such a long history, little surprise need be felt that a system of tillage based on experience should have reached a stage beyond which further progress was bound to await scientific discovery. . . . The cultivator in the main, met new demands by breaking up new areas rather than by intensification of method, the employment of more efficient implements or the use of manures. He requires all the help which sciences can afford and which organisation, education and training can bring within his reach."

The Imperial (now Indian) Council of Agricultural Research was set up in 1929 to promote, guide and co-ordinate agricultural research throughout India. A number of commodity committees were set up to deal with particular crops. Yet the gravity of food situation by 1940 became serious. Government had to initiate "Grow More Food" campaign in 1944. Food crops cover about 75 percent of the cropped area. Yet the yield per acre by the end of 1949-50 was only 565 lbs. (First Five Year Plan, p. 155).

Five Year Plans:—Planning Commission was set up in March 1950 to draft a plan of development for a period of five years. The basic objective of India's development is to provide the masses of the Indian people the opportunities of a good life. With this objective the First Five Year Plan accorded a pride of place to programme for agriculture and community development. In 1953 an intensive campaign in favour of Japanese method of rice cultivation was started all over India. By the end of the First Five Year Plan in 1955-56 agricultural production rose by 17 percent. But this was accompanied by some decline in food grains which account for about 67 percent of the total value of agricultural production (Second Five Year Plan, 1956, p. 257).

The Second Five Year Plan started with special emphasis on heavy industries. However, through the community development, the energies of each village community as a whole was sought to be harnessed and its manpower and other resources effectively mobilised. Yet by the end of the plan period in 1960 the increase in agricultural production was only 16 percent (Third Five Year Plan, p. 302).

The Third Five Year Plan started with task of mobilising the rural community for intensive agricultural development. All families in the village, especially those engaged in agriculture were involved in the agricultural effort through the village Co-operatives and Panchayats to achieve larger results through the village production plan. Intensive Agricultural District programme popularly known as "Package Programme" started operating since 1960-61. Intensive Agricultural Area Programme was launched for development of important agricultural crops. The Ministry of Food and Agriculture established a seed corporation with the object of ensuring production at selected centers under conditions of efficient management and maintaining purity and maximum yield.

There are sixty five universities in India which have taken up post-graduate studies in science and humanities. Education at all levels have been so broad based as to harness the energies of the people and to develop the natural and human resources of every part of the country. Seven Agricultural Universities have been established to provide well organised pattern of service through integration of teaching, research and extension.

Yet the agricultural production has increased only at the rate of 2.1 percent as against 3.0, 3.5 and 5.7 per cent per year by Italy, Australia and Greece respectively with less arable land per capita and farm land inferior to India (F.A.O., 1960).

Rice the hope of millions:—I will deal with the production of rice only. It along with wheat, contributes 62 percent of the total cereal production in India. The production of rice and wheat is roughly in the proportion of 3.5 to 1. Rice occupies 30 million hectares of land extending from the southern most corner of Kerala to the northern most area of Kashmir with annual production of 30 million tons of rough rice. It has been with the people of India from the neolithic age. It has inspired religion and shaped societies. The economy of the Indian farmer is bound up with the harvest of rice. Yet the per acre yield of the crop since 1895 shows no trend of impressive improvement. As a result the Government has to import cereals of the order of 3.2 million tons in 1958, which mounted to 4.5 million tons in 1963 and 7.5 million tons in 1965.

Why this slow progress:—What are the causes of failure of public programme to transform the traditional agriculture into highly productive sector? These may be (i) attitude of the farmers to technological change. The farmer looks to the farming as a way of life. The incentive for transition from subsistence production to production for market is not alluring. The fluctuations in the prices of the products on which he relies for his cash income puts him at a disadvantage to improve his subsistence production. (ii) Lack of agricultural *fundamentalism*—Lack of appreciation of the fact that agriculture is the basic sector of economy, that farm people possess social values superior to those of the rank and file of urban people and that family farm is the natural economic unit in farming (Lauren Soth, 1957). The appreciation of agricultural *fundamentalism* is well illustrated by the achievement of U.S.A. in agricultural sector. Agriculture has become a powerful engine of growth. (iii) The conflict between agricultural approach and industrial approach. The two policies are not necessarily incompatible in long term and are jointly viable. An industrial society, also, has the finest country side to show. The difference lies on the emphasis given to each. This is exemplified by Mexico where agricultural production is increasing at the rate of 7.1 percent per year. This is not due to industrialising the country at the expense of agriculture. It modernised both agriculture and industry and winning large increase in national income from both (Schulz, 1964, p. 19).

Means for changing the attitude of the farmers:—New useful knowledge and new useful skill are the two means for changing the attitude of the farmer. These are investment in the human capital. Yield increasing inputs are the new useful knowledge. The farmer calculates the price of the new factors and the profit that he will get from them before he changes his attitude and adopts them. Here are the opportunities for agricultural scientists to give the farmers the new knowledge of yield increasing inputs.

The yield increasing inputs:—Rice yield per acre in the United States increased from a five year annual average of 1,091 pounds per acre

in 1899 to 3,563 pounds per acre in 1963 (U.S.D.A. Agri. Handbook No. 289). Yield per acre in Japan increased from 12.52 koku per hectare in 1881-87 to 25.12 koku per hectare in 1960-63 (Takashi, 1963). This gradual increase in yield per acre is due to (1) high yielding variety that can take high fertility level (2) fertility control (3) irrigation and water management (4) better cultural practices including rotation and weed control (5) better machinery (6) control of disease and pests and (7) skill and know-how of the farmers. An emergent country like India can transform her traditional agriculture and produce an abundance of food by providing these yield increasing knowledge, incentive and rewards to farmers.

NEED FOR HIGH YIELDING VARIETIES

4000 varieties of rice are grown in the different parts of the country. With systematic research programme financed by I.C.A.R. since 1932 more than 445 superior strains giving an average 10 to 20 percent better yield than the farmer's varieties are now available. Yet a school of agricultural scientists hold the view that there is need for modification of plant type to exploit to the fullest extent the increased fertility level of soils promoted by application of fertilisers and to make more efficient use of sunlight for photosynthesis. The tall-*indica* varieties that are grown for centuries in India offer little hope for substantial yield increase through the use of fertilisers and other applied technology. The increased availability of nitrogen results in excessive vegetative growth which brings about premature lodging without any increase in grain yield. Potentially high yielding varieties, therefore, will meet the need.

Hybridisation approach :—The dwarf-*indica* and *japonica* varieties are panicle number type and are capable of utilising higher doses of nitrogen, 100 to 125 kg nitrogen per hectare and their average yields are 6,250 kg per hectare. So the emphasis was for strains which besides being high yielding also respond well to heavy manuring. A comprehensive programme of hybridisation between *indica* and *japonica* was taken up under the scheme sponsored by the Indian Council of Agricultural Research and F.A.O. Sound progresses has been made with *indica-japonica* crosses towards the development of hybrids with strong straw and high response to fertility. ADT 27 of Madras, H.R. 99 and C.R. 2002 of Cuttack are the outstanding ones.

Mutation approach :—Since all genetic variability ultimately results from mutations, induction of mutations may lead to production of varieties with characters not to be found in natural occurring individuals of the species. G.E.B. 24—a popular rice variety of South India is known for its fineness of grain, high yielding ability and wide adaptability. The only draw back is that it is a late maturing variety which prevents availability of the same land for *rabi* crops. Rao and Ayengar (1965) have reported a mutant of G.E.B. 24 from the Biological Division of Atomic Research Establishment, Trombay. The chief attributes of this true breeding mutant are early maturity (three weeks over control), increased grain frequency per panicle (260 as against 180 in control) and high yield (10 to 19 percent over control).

Erectoid plant type approach :—Erectoids derived from dwarf-*indica* varieties usually have short stiff straw with profuse tillering and are more lodging resistant than the parent ones. Taichung Native—1 evolved in Taiwan is such an erectoid dwarf type. It has been introduced to India since 1965. It is high yielding and under favourable conditions it can

use 125 to 150 kg nitrogen per hectare and give an yield of 5 to 7 tons per hectare. Variety IR 8-288-3 of International Rice Research Institute, Philippines, is another erectoid short variety. The tropical *Japonica* like Tainan 3, Taichung 65 and Chianung 242 exhibit wider adaptability and are less sensitive to photoperiod and high temperature conditions. They demonstrated excellent yielding ability and nitrogen responsiveness in both *Kharif* and *rabi* season.

In the high yielding varieties programme with rice crop too much emphasis is being given on plant types. The true yield variability of this new factor, the new elements of risk and uncertainty that such types involve are less known while that of the old factor farmers own *indica* and improved *indica* varieties are well known from experience. Farmers with subsistence farming are less able to cope with such additional risk and uncertainty than are farmers in high income countries.

In the high yield contest, the *Krishi Pandits* in India have obtained rice yields varying from 4,586 kg to 19,934 kg rough rice per hectare with the local and improved tall-*indica* varieties (Table I). These highest yields obtained by *Krishi Pandits* in different parts of the country indicate that (i) better varieties of seeds is not the primary importance for obtaining high yield. The yield differences are due to the environmental conditions, manurial and cultural practices. Studies on increased production during 1956-61 revealed that 13 percent of the increase was attributed to improve seeds, 41 per cent to fertilisers, 27 percent to water control and management, 9 per cent to improved cultural practices and 10 percent to land reclamation and double cropping (Thapar, 1964). Japan ranks seventh among the World's rice producing countries in area, third in rice production but ranks first in rice yield. The high rice yields are not solely due to more fertiliser responsive varieties but due to the favourable environment, highly intensive culture with heavy fertiliser application, better controlled irrigation and much labour input.

Environmental regime : Production of crops is the result of the co-ordinated interplay of the heredity factors and environmental conditions upon the internal physiological process of the plant. The intermediate stage between the genetic constitution and environment on one hand and the organic development on the other hand is an intricate one, and our present knowledge has not completely solved it (Meyer and Anderson, 1960).

Environmental factors have no direct effect upon the genetic makeup but they exert a profound influence upon the expression of its heredity. A plant is at once affected by the amount of heat, light, moisture and nutrient available to it and by the degree of activities of insect pests and diseases. When the intensity of any one of these factors begins to tax the plant's ability to cope with it, vigour declines and production is low.

Temperature and light are the two important factors of environment. Early maturing varieties distributed in cold region are high in thermo-phase and low in photoperiodic response. In contrast to this late maturing varieties distributed in warm regions are low in thermo-phase and high in photoperiodic response (Matsubayashi *et al.*, 1965). In India the temperature in the main rice growing season starts with about 30°C in June and declines to 22°C in November while the second season starts with 18°C in January and ascends to 27°C in April. Dwarf-*indica* Taichung Native—1, therefore, flowers in about 75 days in main season and in about 102 days in second season. Temperature has nothing to do with photosynthesis of rice plant but temperature co-efficient for respiration of rice plant is generally accepted as 2, though varying in growth

stage. This has an important bearing on dry matter production of rice plant.

Day length in main rice growing season starts with 13.0 hrs. in June and decreases to 10.7 hrs. by November while in the second season it starts with 11 hrs. in January and ascends to 12.5 hrs. in April. Photo-nonsensitive dwarf-*indica* and tropical *japonica* when sown in the main season grow in decreasing day length from June to September and receive about 500 effective sunshine hours in 130 days. These varieties when sown in spring from January to April grow in increasing day length and receive about 1,050 effective sunshine hours in 130 days. The yield of these photo-nonsensitive varieties is, therefore, low in *kharif* and high in spring season. These photo-nonsensitive varieties are, therefore, to be grown as spring crop and the area during *kharif* season should be reduced as far as practicable.

Untimely heading : The dwarf-*indica* Taichung Native—1 and tropical *japonica* varieties exhibit a peculiar behaviour during *kharif* season. In a few weeks after transplanting and in the midst of vigorous tillering the main plant sprouts a head. It occurs in seedling when planted after 4 to 5 weeks from date of sowing in the nursery bed. This untimely heading is due—to older seedlings, under-nourishment in the seed bed and high temperature prevailing during early stage of growth. Planting of two to three weeks old seedlings is of importance with these varieties. But the environmental factor that determines the time of planting in non-irrigated areas is the start of monsoon. Taichung Native—1 and tropical *japonica* varieties, therefore, can be grown in limited areas during *kharif* season with irrigation and better control on water management.

Ideal plant type for India : In India where rice has to be planted in June after monsoon starts and harvested from September to December, varieties which can make most of the low light intensities, long days and rain during flowering time need to be developed. Even if planting is delayed these non-sensitive long maturing varieties will give higher yield.

Non-lodging character seems to be the most important single character in rice contributing to higher yield. Varieties which yield only 2,000 kg/ha and lodge badly at Cuttack, do not lodge in Kashmir and give 5,000 kg per hectare. Kaohsinug 22 which has not erect leaf has given as high yield as 10,000 kg per hectare at the Almora Hill Station (Misro, 1965). Breeding for strong straw is, therefore, of prime importance for increasing per acre yield and mechanisation of rice cultivation. Here lies the opportunity for Biologists to make their contribution.

SOIL FERTILITY AND RICE PRODUCTION

Fertility status of Indian soils : There is no gainsaying the fact that the fertility status of Indian soils is extremely low. A summary of soil test data of soil samples collected from different States has shown that over 60 per cent of soil are poor, 23 per cent of medium and 17 per cent of high fertility in nitrogen, phosphorus, potash and organic carbon. On an average there is 0.03 to 0.07 per cent nitrogen and 0.6 per cent organic carbon in Indian soils as against 0.10 to 0.17 per cent nitrogen and 3 per cent organic carbon in European and American soils (Mukherjee and Agarwal, 1950). Organic matter, nitrogen, phosphate and potash must be supplied to the soil for increased production.

Dynamic aspect of flooded soils : Rice is cultivated under conditions of flooding for about four to five months during its growing season. This

flooding brings about profound change in the physical, chemical and biological status of soil. Late maturing varieties face the problem of toxicity of substances where drainage condition is poor. The physiology of rice plant is altered. In the latosol and yellow podsollic soils, which are poor in nutrient, 'Bronzing' disease similar to 'Mentek' in Java, 'Akagare' in Japan and 'Bruzone' in Italy occurs. Application of organic manures and sulphate carrying fertilisers aggravates 'Bronzing'.

Rice does not have a critical soil pH requirement. But the best producing soils have values between 5.5 to 6.5. Flooding has been found to increase the soil pH. At Bhubaneswar, Orissa; the pH increase in flooded latosol varies from 0.75 to 1.50. Application of organic manures and prolonged use of ammonium nitrogen source increase soil acidity.

Flooding brings about change in oxidation-reduction status, specific conductance and deflocculation. The oxidation-reduction layer modifies plant environment and must be taken into consideration in green manuring, fertiliser application and water management.

MANURES AND FERTILISERS

Nutrient removal by rice crop : Rice makes great demand on the three major nutrients—nitrogen, phosphorus and potash. The nutrients removed in rice growing with a grain crop of 1,000 kg per hectare are 15 kg N, 10 kg P_2O_5 and 30 kg K_2O during one crop season. (Glander, 1957) It is not possible for even a fertile soil to supply indefinitely adequate quantities of necessary nutrients without becoming impoverished. The yield of the crop, therefore, has remained at the same level for long. This is due to a state of equilibrium that has been established in course of time between cropping level, the nutrient removal and the ability of soil to furnish nutrients. Proper use of manures and fertilisers increases the yield of rice from 30 to 50 per cent depending upon soil type, varieties, irrigation and drainage and management practices. This is also one of the factors that is primarily responsible for large differences among countries in the success of agricultural sector.

Organic manures : For tropical soils sufficient humus is of outmost importance as only thereby the basic condition for successful fertilisers application is created. In tropical soils the clay materials with a higher buffer effect are very often lacking. In addition, the regulating effect of phosphoric acid is prevented by the presence of large quantities of sesquioxides (Scheffer, 1959). Farmers in Japan always use organic manures with fertilisers. China is the largest user of organic manures and utilises 70 per cent of the 200 million tons of available night soil. 50 per cent of agricultural land receive night soil and stable manure, 20 to 30 per cent compost and 10 to 15 per cent green manure. Crop production in China is, therefore, higher although the lands have been cultivated for thousands of years. (Dhar, 1961)

At the Agronomy Section, University Experiment Station, Bhubaneswar, Orissa, a long term continuous growing of rice with and without organic manures superimposed with nitrogen-fertiliser has been started since 1956. The original carbon and total N content was 0.663 and 0.029 percent respectively. In 10 years these have dropped to 0.579 and 0.021 percent respectively, in the unmanured plot and to 0.600 and 0.32 in commercial fertiliser plot while by adding cowdung manure and green manure @ 4,000 lbs per acre every year the organic carbon and nitrogen status improved to 17.6 percent and by green manure to 1.5 percent. Built

of fertility of soil is, therefore, more with cowdung than green manure. Unfortunately major part of cowdung is used as fuel. It is the Agricultural Engineers who can develop Cowdung Gas Plant and, thereby, make more cowdung available for the rice fields.

Green manuring and green leaf manuring : Green manuring is the cheapest form of manuring rice crop. This practice is to be intensified wherever facilities exist. Climatic factors stand in the way of growing green manure crops before the rice crop is transplanted. Green leaf manure is the next alternative. Sannhemp, *Sesbania, aculeata* (Dhaicha), *Sesbania speciosa*, *Glyricidia maculata*, and *Ipomea cornea* can be applied at a rate of 4,500 kg per hectare. Application of 22.5 kg P_2O_5 per hectare at the time of incorporation of green leaf enhances rice yield. (Sahu, 1965).

The result of long term manurial trial at Bhubaneswar, Orissa, show that if organic manures are applied at a dose to supply 22.5 kg nitrogen per hectare, further application of nitrogenous fertilisers does not add to the yield to the same extent as obtained when fertiliser is applied without basal dressing. With limited availability of fertiliser, maximum benefit will be obtained by using organic manures and nitrogenous fertilisers in separate fields.

Yield of rice with and without basal dressing of organic manure (kg/ha).

Treatment kg N/ha	Without basal dressing	With basal dressing	Response	% - Increase
Nil	2,165			
22.5	2,344	2,400	56	2.39
45.0	2,361	2,469	108	2.75

Organic manures, however, aggravate physiological disease in low land water-logged soil. Bronzing disease of rice under water-logged soil is brought about by application of organic manures. Reduced conditions are created. Iron and manganese become more soluble and thereby toxic to rice plant. For lowland water-logged rice soil green manuring, cowdung or compost are not essential for higher yield.

FERTILISERS

Nitrogenous fertilisers : Of the three essential nutrients the highest need for rice is nitrogen and the response to nitrogen is practically universal throughout the rice growing areas of India. The all India fertiliser trials in the cultivators' fields have shown that the average response to nitrogen applied at 33.6 kg/ha works out to be 325 kg/ha. Except in Himachal Pradesh, in all other States the responses are good, ranging 260 kg/ha in Maharashtra to 390 kg/ha in Madhya Pradesh. In Himachal Pradesh the response was 140 kg/ha (Seth and Abraham, 1965).

Forms of nitrogen : It has been reported by a number of workers that for rice ammonium ions are better source of nitrogen than nitrate ions. Prevalence of many new nitrogenous fertilisers has posed new problems concerning their suitability under varying soil and climatic conditions. Field trials conducted at Bhubaneswar, Orissa, on the efficiency of nitrogenous fertilisers reveal that for lowland rice ammonium sulphate is best followed by ammonium phosphate and ammonium chloride. Ammonium

sulphate-nitrate, calcium ammonium nitrate and urea have comparatively lower efficiency as compared to the former three fertilisers (Mahapatra and Sahu, 1963).

Since rice is grown in more acres and receives more fertiliser than any other crop, fertilisers compatible on rice should be given preference in India's Plan for domestic production. The fewer the number of types of fertiliser, the most efficient use of them can be taught to farmers and extension workers.

Time of application of Nitrogenous fertilisers : The Japanese workers put forward a theory of nutrioperiodism in rice according to which nitrogen is needed by the rice plant at early stage, phosphorus at tillering and potassium at ear formation (Tuneya, 1961). Studies made at Agronomy Department, Bhubaneswar and elsewhere in India show that tail *indica* varieties do not exhibit such phenomena. The use of higher dose of nitrogen, however, makes the timing of such application more important. Split application is also desirable from soil retention, ability of the rice plant to utilise effectively and to avoid luxury consumption with excessive vegetative growth and danger of lodging.

Method of application : For upland varieties nitrogenous fertiliser is to be broadcasted under moist condition of soil after weeding the crop. For medium and late varieties and under low land conditions subsurface (plough soil) application minimises leaching and denitrification and ensures better depth distribution of nutrient and higher recovery by rice plants. Wherever possible and in row planted crop, the field is to be drained ; the fertiliser is to be broadcasted on the surface followed by interculturing with a Japanese rotary weeder. Where the field can not be drained pellet application to be adopted.

Response to phosphatic fertilisers :—Response of rice to phosphate is not so marked as response to nitrogen applied on equal dose basis. The efficiency of phosphatic fertilisers is, to some degree influenced by soil type, kind of fertiliser, rate, time and method of application.

(i) *Soil types* :—Relative mature soils containing more of iron and aluminum bound phosphorus are more responsive to phosphate application than the immature soils that are richer in calcium bound phosphorus. The all India fertiliser trials in the cultivators' fields have shown that response to phosphate (22.5 kg/ha) is good (342 to 429 kg/ha) in red, black, red loam and laterite soil ; moderate (264 to 342 kg/ha) in alluvial soil high in lime and other alluvial soils of Bihar, Orissa and Punjab and low (150 to 264 kg/ha) in deep black, coastal, sandy and hilly soils (Anon., 1963). Response to phosphate is more under flooded condition than under upland condition. In the upland laterite soil response of rice to phosphate is more in limed than in unlimed soil (Sahu, 1965).

Sources of phosphate :—Phosphate is usually applied in the form of superphosphate. Rockphosphate (100-150 mess) gives better response in acid latosol soils. Nitrophosphate and hyperphosphate give poor response. Dicalcium phosphate is very costly.

Time of application :—Rice makes use of soil and added phosphate. In the early stages of growth, when the level of available soil phosphorus is low the plant makes use of more fertiliser phosphorus. Towards ear initiation stage the uptake is more from soil phosphorus. Phosphates should, therefore, be applied as basal dressing. There is evidence that rice responds to top dressing to be done at the maximum tillering stage—one month after *Beushan* or transplanting.

Method of application :—Under upland condition and semi-dry system drilling is better than broadcasting. The latter method stimulates weed

growth. Under transplanting system broadcasting of bonemeal, rock-phosphate and dicalcium phosphate at puddling or pellet application of superphosphate gives higher response (Sahu, 1960).

Response to potash :—All India fertiliser trials in cultivators' field indicate that special areas have shown response to potash. The response on the red and yellow soil is higher than that of other soil groups. On alluvial, red latosol and sub-montaneous soil response to potash is usually slight (Anon., 1963).

The total amount of potassium in rice grain and straw is about 58.58 kg/ha. Growing rice intensively and more productive varieties like dwarf-*indica* and tropical-*japonica* necessitate high dose of potash application.

Lime and other soil amendments :—

“Manure and fertiliser without lime

Will ruin the farm and farmer in time” (Emily Truog).

Rice does not respond to lime. Experiments conducted at Bhubaneswar (Orissa) and in Bihar indicate that application of lime to the legume crop grown in rotation with upland rice crop increases the nitrogen content of soil. The yield of legume as well as the succeeding rice crop increases. Lime seems to be most useful amendment for upland laterite soil for increasing rice yield (Sahu, 1965).

Application of lime in the waterlogged rice field reduces the intensity of iron toxicity and root rot disease of rice (Sahu, 1966). Application of lime is, however, costly. But basic slags from Factory and soda-lime waste of Paper Mills can be used as effective substitute for lime.

CORRELATING SOIL TEST AND FERTILISER NEED

Various chemical and rapid soil-test methods are used in determining the manurial and fertiliser requirement of a crop. However such rapid tests on dry soil have been found not of much use in rice soils except in limited areas. Flooded conditions in which rice is grown creates conditions in which (i) marked increase in nutrient availability takes place and (ii) reduction products impede nutrient uptake. Soil solution is the chief source of nutrition of the rice crop. Dynamics of flooded soil is quite distinct from that of a dry one. Field experimentations and activation analysis of soil solution at critical stage of growth of rice provide reliable data on manurial and fertiliser requirement of different soil types. (Ponnamperuma, 1965).

Lessons from other countries :—Manures and fertilisers help in building up fertility of soil and raise productivity. 25 per cent of U.S.A.'s food products comes from the fertiliser resources. Fertiliser is becoming an extremely important substitute for labour, land and other particular forms of capital. Countries leading in higher per acre production of rice have done so by liberal use of commercial fertiliser along with organic manures. In 1963-64 fertiliser consumption per hectare was 297 kg in Japan, 210 kg in Taiwan, 178 kg in South Korea, 135 kg in France, 95 kg in U.A.R., 84 kg in Italy, 51.6 kg in U.S.A. Whereas it was only 3.46 kg in India.

What India's fertiliser consumption target to be :—Government of India should, therefore, undertake a very ambitious programme of fertiliser manufacture on a high priority basis and a much higher target of fertiliser use to be fixed in the Fourth Five Year Plan.

Cost yield ratio less favourable to Indian farmers :—Fertiliser use in India is limited by cost yield ratio. The farmer in India pays more for fertiliser but gets a lower price for his crop. A farmer in Europe pays Rs. 1,190 per ton of nitrogen for ammonium sulphate against 1,800 in India and Rs. 760 per ton of P_2O_5 for single superphosphate against Rs. 1,520 in India. As a consequence the fertiliser is used more on higher priced cash crops than on food crops.

Our educational and extension work during the last 15 years of planning has created a substantial demand for this input. But from the farmers point of view, the cost of fertiliser is a function of the exchange rate of rice against fertiliser and yield per hectare. The average yield of rice per hectare in India is 1,150 kg as against 4,750 kg in Japan. The cost of one kg of NPK in terms of rice is 5 kg in India as against 1.05 kg in Japan.

Relative cost of fertiliser in India=

$$\frac{\text{Yield of rice in Japan}}{\text{Yield of rice in India}} \times \frac{\text{Cost of 1 kg NPK in terms of rice in India}}{\text{Cost of 1 kg NPK in terms of rice in Japan}}$$

$$\frac{4,750 \text{ kg}}{1,150 \text{ kg}} \times \frac{5.0 \text{ kg}}{1.05 \text{ kg}} = 19.6$$

The farmer in India is burdened by the fertiliser cost 19.6 times more heavily than in Japan. The Japanese farmer, therefore, has terrific advantage as compared to the farmer in India. Scientists, fertiliser manufacturers, Distributors, Economists and Government may study this aspect of the fertiliser use promotion.

IRRIGATION AND WATER MANAGEMENT

The essential input besides seeds and fertiliser is irrigation. Rice is a semi-aquatic plant. It will not produce a profitable crop on stored soil moisture or under infrequent rains as will other cereals (Adair *et al*, 1962). The upland paddy varieties which are rainfed, therefore, generally result in lower yield than the irrigated ones. In the upland culture the plant crowns are exposed to higher temperature and to greater daily fluctuation in temperature than when grown under irrigated and flooded condition. Such exposures weaken tillering. As a consequence yield is reduced.

Senewiratne and Mikkelsen (1961) conducted a comparative test for growth and nutrient absorption of rice plants between upland and flooded condition. The rice yield in the upland plot accounted for 52.6 per cent of those in submerged plot. They suggested the growth differences in auxin metabolism. Plants grown under upland condition had a low catalase activity and high peroxidase activity which favoured accelerated auxin degradation. The manganese content of rice plant grown under upland condition was very high. This higher level of manganese affected the indoleacetic oxidaes mechanism and resulted in the retarded growth and depressed yield of the crop. Clark *et al* (1957), however, have reported that favourable effect of flooding on rice in some soils is due to better manganese nutrition.

Sahu and Rout (1965) have reported the effect of three soil moisture regimes on the growth and yield of long duration tall-*indica* rice T.1242.

Submergence with 15 cm standing water enhanced height, foliage development, dry matter accumulation, earlier flowering, maturity of the crop and increased yield in comparison with soil moisture at field capacity and 75 percent of available moisture. Rice crop, therefore, requires soil moisture above field capacity for better growth and higher yield.

Water requirement and consumptive use of rice :—Rice is semi-aquatic. Its water requirement is, therefore, larger than any other cereal crop of similar duration. The water requirement of rice crop varies from 40-90 care inches depending upon duration of the crop (Ramiah *et al*, 1951 ; Pandey, 1956 ; Vachhani, 1963). The consumptive use varies from 500 lbs to 1,000 lbs per pound of dry matter depending upon the soil, variety, manure and cultural operations.

Water requirement and consumptive use of rice are influenced by soil moisture regime above or below field capacity. The water requirement of 'Sarad' crop under Bhubaneswar condition when rice crop is transplanted in second week of July was 62,32 and 28 acre inches in 140 days under 15 cm standing water, at field capacity and under 75 percent available moisture respectively. The consumptive use—gram of water utilised to produce one gram of dry matter—was 1,493, 1,084 and 931 gm under these three moisture regimes (Sahu and Rout, 1965).

Influence of manuring :—Water requirement and consumptive use were reduced with increasing fertility level of soil. The reduction was in proportion to moisture regime. The yield of the rice crop was reduced with reduction in moisture regime (Sahu and Rout, 1965).

Water requirement, consumptive use and yield of rice crop as influenced by manuring and moisture regime. (Rice T.1232).

Moisture regime	water requirement in acre inches		Consumptive use gm of water		Yield, kg/ha	
	Unferti- lised	Ferti- lised	Unferti- lised	Ferti- lised	Unferti- lised	Ferti- lised
15 cm standing	60	62	1493	1128	3596	4120
Field capacity	32	32	1084	860	2857	3507
75 percent moisture	26	28	931	748	2538	3189

Critical period of water requirement :—Pot culture experiment at Bhubaneswar with MTU 15 during spring and T.1242 during main season has indicated that there are three critical phases in the life of rice plant, namely (i) tillering phase, (ii) ear primordia initiation and heading phase—30 day period from 20 days before heading and 10 days after heading, (iii) grain filling phase. These three phases are susceptible to moisture stress and therefore most effective phase for irrigation.

Water management :—Application and management of water is very important in rice farming. Three main lines of approach is necessary, namely (i) measures against too much of water (ii) measures against too little water and (iii) the most adequate watering methods under ordinary conditions for getting maximum yield.

The field requires flooding when the seedlings are 10 to 15 centimeters high to prevent weed growth. After interculture of broadcasted or drilled rice and also after transplantation the field must have water to a depth of 5 to 7.5 centimeter for control of weeds. Fields are to be drained by first week of September for control of algal growth (scum), aquatic weeds

and insects and top dressing of fertilisers. As the plants grow taller, the depth of water gradually to be increased until it reaches 10 to 15 cm. Flowing of water is better than stagnant water. It is important to hold water on the land long enough to permit the rice to reach proper maturity.

Need for development of irrigation :—Rice is grown in areas having an annual average rainfall of over 1,250 mm. Irregular distribution of rain is, to a large extent, responsible for fluctuation in yield. Rainfall that increases from sowing of the crop to milky stage and then decreases till the crop is harvested is considered to be ideal one. But unfortunately one out of three years is either drought or flood. A developing country with growing population can not depend upon natural rainfall for crops. The area under long duration photo-sensitive varieties are to be reduced and area under short duration photo-nonsensitive varieties like ADT 27, Ptb—10, MTU 15, TKM 6 and medium duration photo-sensitive G.E.B. 24 mutant and T. 141 to be increased to achieve greater yield. In the precarious rainfall areas where upland rice is grown and yields are exceedingly low facilities for irrigation is to be improved failing which new cropping pattern is to be adopted. Ways and means are to be explored for maintaining an even water supply to monsoon-fed areas.

Irrigation needs development. India has its snowfed perennial rivers. The whole of the Gangetic plain and the coastal belt nourished by the Mahanadi, Godavari, Krishna and Cauvery will not only make the area self sufficient but also feed the rest of the country. Underground water need to be tapped. Shallow and deep wells to be dug. Rural electrification will provide electricity so that whatever water available can be pumped out into the field.

Drainage :—When land is irrigated drainage problems almost always follow. There are vast areas in Orissa and Kuttanad and Kole areas of Kerala which are unique paddy growing regions. But they are sub-merged for major part of the year. There are areas in Punjab where water table is rising. Such areas need attention. Conditions to be assessed and steps to be taken to correct the situation. In Japan water is pumped out from sub-merged areas and utilised for irrigation of high lying areas. Subsurface drainage is to be improved.

Saline and alkaline problem :—Entry of water from the back waters is a menace in the coastal areas of Orissa, Andhra, Madras and Kerala. Alkalinity is a problem in U.P., Punjab and Rajasthan. Varieties of rice differ in tolerance to salinity but all are affected by salt concentration of the soil solution in the root zone. Rice seedlings are very sensitive to salinity in early stages of development but become resistant at 3 to 6 weeks of age. Tolerant varieties like SR 26 of Orissa are to be developed. Water containing more than 600 ppm should not be used to irrigate rice. Finfrock *et al.* (1960) have suggested standard for water to be used for irrigation as follows :—

Specific electrical conductivity ($K \times 10^8$)	less than 750
Boron ppm	less than 1
S. A. R. (tendency to form alkali soil)	less than 10

CULTURAL PRACTICES

Improved varieties and application of adequate quantities of fertilisers give better crops. But cultural practices like date of planting, spacing and rate of planting influence the internal physicochemical characteristics

which constitute the vital characteristics of the plant. There is interaction of nitrogen and phosphate with cultural practices relating to date of planting, spacing and rate of planting.

Drilling to be popularised : There is a common belief that yields of transplanted rice is generally higher than those from direct sowing. There is accumulated experimental evidence that the yield obtained from transplanted crop did not differ significantly from that of drilled crop. Transplanting is, therefore, to be confined to areas where labour supply is plentiful. Three key operations in rice culture namely transplanting, weeding and harvesting require the maximum quantum of labour. Rice is very sensitive to delay in transplanting. 75 per cent of area under rice is broadcasted and 25 per cent of area is transplanted under irrigated condition. Recently as Britain's contribution of the Rice year a mechanical paddy transplanter, designed by the Overseas Liaison unit in co-operation with the National Institute of Agricultural Engineering, was demonstrated at Budhi, Madhya Pradesh. It can transplant 2.5 acres working for eight hours in a day as against the one acre covered by 25 workers by hand and about 32 labourers in row transplanting in Japanese method of rice cultivation. But the transplanting machine is complicated. Adjustment of spacing for tall and dwarf-*indica* varieties will be difficult. Drilling has been found equally effective as transplanting. Japan is now adopting direct sowing technique and direct sowing machine is now being brought into practical use. With this machine seeding and fertiliser application are done together in a manner patterned after the wheat crop seeders. There is, therefore, need for designing of seed drill for sowing upland and lowland rice and to suit different soil types. Here is the opportunity for Agronomist and Agricultural Engineers to devise seed drill.

Rotation or cropping system : The long term fertility trial conducted on rice has shown that under continuous cropping of rice the soil usually becomes depleted in fertility and organic matter. Follow/rice rotation has given lowest yield. Where two leguminous pulse crops like *mung* or *blackgram* have been introduced in the *rabi* season, the yield of rice has not only increased when grown in subsequent *kharif* season but also the yields of pulse crop have gone fairly high. The yield of rice has increased to 2,657 kg. against 1,996 kg per hectare (Mahapatra and Sahu, 1962.)

In another series of trial (1) blackgram-rice-black gram (2) maize-rice-maize and (3) sesamum-rice-sesamum and (4) fallow-rice-fallow, the beneficial effect of legume in the rotation was confirmed. The increase in yield of rice was 14.5 per cent. Maize and sesamum had depressing effect. Oilseed-rice rotation gave low total yield per hectare. Positive gain in organic matter and nitrogen was under legume-rice rotation (Sahu, 1965).

Weed control in rice fields : The problem of weed is as old as agriculture itself. One grass plant per one thousand square centimeter area reduces the rice yield by 750 kg per hectare (Agri. Hand Book, p. 289). The loss due to weed infestation is the major cause in the potential yields of rice.

Much can be done to control weed growth where water supply can be managed effectively and hand weeding feasible. With the rising cost of manual labour, the science of chemical weed control has gained importance. The response to chemical weed control is of the order of about 15 to 20 per cent in production of rice. This compares favourably with the response in yield with application of nitrogenous fertilisers. Upland rice is usually sown on dry and unflooded land. The erratic germination of weed in the upland condition reduces the effectiveness of weedicides. However presowing application of amine salt of 2, 4-D @ 2.4 kg. a.e. per

hectare or post emergence applicaton of propanil @ 3.5 kg. a.i. per hectare followed by one hand weeding is the most effective method of controlling weeds.

In transplanted areas germination of weeds come prior to transplanting. So the weeds are eliminated mechanically by puddling. Later weed growth is usually controlled by constantly flooding and hand weeding. With row planted crop working of Japanese rotary weeder is more effective.

In broadcasted crop which covers more than 75 per cent of the area germination of weeds come after sowing of rice. Intercultural operations do not kill all weeds. Post-emergence application of translocated herbicides like amine salt of 2,4-D and MCPA @ 1.6 kg. a.e. per hectare and contact herbicide like propanil sprayed @ 3.5 kg. a.i. per hectare followed by *Beushan* or *Biasi* practice greatly increases the effectiveness of weed control.

Drift hasards of weedicides on other crops are severe. High volatile esters are toxic. There should be State Regulations and Law as to weedicide formulation, equipment, responsibility and liability before the weedicides are advocated for use in large scale.

Improvement in farm machinery and farm implements and their popularisation : Hand tools and animal driven implements are the chief source of power for land preparation to harvesting and threshing of the crop. There is now labour shortage in rural areas with the advent of modern urban industries. The Fourth Five Year Plan envisages agricultural revolution in the county. This implies forsaking of traditional agricultural practices to which the country has been moored so long. But caution is necessary in the mechanisation of rice culture. Machinery and implements should be developed for each specific cultural operation and according to farmers size, class and locality. Mere possession of improved implements does not mechanise agriculture. Selection of implements and machinery is more important because on the suitability or otherwise of these machineries depends the success or failure of mechanisation. The need to evolve some economical type of implements is of prime importance and has to be given due weightage to Agricultural Engineering Research. More work is needed to evolve some good implements and machinery so that they can be used practically and economically on the smaller holdings of the country.

Control of pests and diseases : Of our crop acreage of 330 million acres we can cover only 22 million acres with insecticides and pesticides to protect crops—from the ravages of diseases and pests which are estimated to cause a loss of about 15 per cent of the crop annually. The severity of attack is influenced by soil and environmental conditions. Introduction of dwarf-*indica* and tropical-*japonica* has brough bacterial leaf blight and certain physiological disturbances. Use of resistance varieties, seed treatment and better cultural practices can control the disease and insects to a great extent.

LAND REFORM

India has adopted democratic socialism as her goal. If socialism is to become meaningful the disparity of income to be reduced. The problem of land relation to be changed. Land relation is the main cause of perennial food crisis. Land ceiling to be expedited. There are voices for development of Joint Stock Companies in Agriculture during the Fourth Plan. I like to quote here the message of President Eisenhower which he gave to the United States Congress in 1956. "Throughout our history

the family farm has given strength and vitality to our social order. We must keep it healthy and vigorous”.

The concept of agricultural production advanced by Marx was strongly based in favour of large farm. The larger the producing unit in agriculture the more efficient it will be. But in Israel, the land is not of high quality yet the production has been high. Modern factors have been important. The *kibbut zim* (large farm) has done well but it has been less efficient than the *moshavim* (small farms) (Schultz, 1964, p. 19). In 1952 Japan passed the Agricultural Land Law which is based on the principal of ownership of farm land by individuals; the acquisition of land by corporation was illegal. In 1962 an amendment to the Agricultural Co-operative Association Law was passed authorising Joint Stock Companies and Agricultural Co-operatives to acquire title to farm land. Yet the land tenure system has become an obstacle to further development of Japanese Agriculture (Take Kazu Ogura, 1966, p. 148). Farm land in Mexico is inferior. Many *ejidos* (small farm) were created by land reform. These could not help in increasing the production. It is the application of science with assistance from Rockefeller Foundation that brought production to high level (Schultz, 1964, p. 20).

It is, therefore, not the land reform but the provision of basic transport and marketing facilities that develop production from subsistence to market type. The importance of transport is well illustrated by the development in Fiji where whole village and individual move to areas better placed for commercial farming. Transport breaks down isolation from outside influence (R. Gerard Ward, 1964, p. 492-493).

RESEARCH AND EXTENSION

Need of continuous research : Provisions of inputs do not end the task. It is necessary to make arrangements for continuous improvements in the quality of inputs. It is the task of the agricultural scientists to take up research that is necessary for improving the quality of agricultural inputs. There is vast scope for the plant breeder to bring new varieties of crops, for agronomist better agronomic practices, for agricultural chemist management of soil, plant physiologist to unveil the behaviour of varieties, for entomologist and plant pathologist to evolve better and economical methods of plant protection and agricultural engineers to invent improved agricultural implements and machinery.

Need for education and extension service : Educational measures are of considerable importance at all stages of transition in modifying attitude and promoting the adoption of new technique. The spread of scientific agriculture is, therefore, closely related to the spread of agricultural education. A recent survey in the United States of America has revealed that 2.5 per cent of 3 million farmers who have spent 8 to 14 years in education are innovators, 13.6 per cent are quick in uptake, 68 per cent who have spent 4 to 8 years in school are less quick while the rest 16 per cent who had less than 3 years education are laggards. Total agricultural production in Japan is eight times that of India. This is due to high level of farming skill and the amount of schooling that the farm people of Japan have acquired compared to low level of skill and general illiteracy that prevails in rural India. Farm Journals and newspapers are not obviously possible when farmers are illiterate. In the United States there are large number of farm Journals, newspapers, radio and television programme that regularly transmit to farm people all manner of technical and economic information.

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Table—Yield of rice (Kg/ha) obtained by Krishi Pandits in India (1952-61)

Region	State	Village and District	Name of the Farmer	Year	Variety	Yield obtained	Manures and fertilizers applied (per hectare)	Reference
Northern	Uttar Pradesh	Basti	Sri Bhanu Pratap	1956	T1	5,326	Fertilizers—56 Kg N as ammonium sulphate and 358 Kg single super phosphate	Ind. Fmg. 6(7) : 4-5
Eastern	West Bengal	Kendua	Sri Syamapada Mukherjee	1954	Raghusail	8,266	Manures—150 Cart loads tank silt+75 cart loads F.Y.M.+40 cart loads cowdung Green Manuring—Sunhemp @67 Kg. seeds/ha Fertilizers—67 Kg. ammonium sulphate+67 Kg. super phosphate+67 Kg. bonemeal	Ind. Fmg. 4(1) : 4-6
-do-	Orissa	Rampur (Puri)	Sri Bhagirathi Misra	1955	T1242	9,000	Manures—15 cart load F.Y.M. super digested with 224 Kg. super phosphate+75 cart loads tank silt+180 Kg. groundnut oil cakes Green Manuring—Dhanicha	Ind. Fmg. 5(10) : 4-6
-do-	-do-	Kendubania (Puri)	Sri Satyabadi Sundara	1955	T1242	9,367	Fertilizers—112 Kg. ammonium sulphate Manures—15 cart load F.Y.M.+80 Kg. bonemeal Green Manuring—Dhanicha	Ind. Fmg. 5(11) : 3
Southern	Madras	Ramnad	Sri Satyanarayan Thever (Ushawa manikam)	1954	—	12,605	Fertilizer—224 Kg. Ammonium Sulphate Manures—Sheep penning+1120 Kg. green leaves +25 cart loads compost+1272 Kg. Groundnut oil cakes+250 Kg. Neem cakes Fertilizers—90 Kg. Ammonium Sulphate+250 Kg. Single Super phosphate	Ind. Fmg. 4(5) : 4-6
-do-	-do-	-do-	Sri Velliah Gounder	1951	—	13,452	Manures—75 cart loads Pangam leaves+62,720 Kg. cattle manure+2,160 Kg. Groundnut cake Fertilizer—1254 Kg. Bonemeal+940 Kg. Ammonium sulphate	Ind. Fmg. 4(5) : 4-6
-do-	Kerala	Trivandum	Sri Vasudevan Pillai	1960	Ptb 10	8,153	Manures—5600 Kg. green manure+4480 Kg. Compost Fertilizers—240 Kg. Ammonium Sulphate	Ind. Fmg. 10(10) : 14-15
Central	Madhya Pradesh	Rithore (Morina)	Sri Sardar Ram Singh	1953	—	11,020	Manures—134 Kg. Groundnut oil cake Fertilizers—670 Kg. Ammonium Sulphate+134 Kg. Super Phosphate	Ind. Fmg. 4(2) : 20-22
Western	Maharashtra	Shivre (Nasik)	Sri Laxman Gopal Mali	1952	—	18,604	Manures—62 cart loads ripe compost+518 Kg. Groundnut oil cake Green Manuring—Sunhemp (44 Kg. seeds/ha)	Ind. Fmg. 3(8) : 4-6
-do-	-do-	Kelava	Sri N. K. Mahatre	1952	K42	7,350-9,180	Fertilizers—200 Kg. Ammonium Sulphate Manures—518 Kg. Groundnut oil cakes Fertilizers—72 Kg. N/ha+11 Kg. Borax+36 Kg. Super	Ind. Fmg. 3(11) : 10-11
-do-	-do-	Banikhamba	Sri Tukaram Patil	1960-61	L.K. 248	10,286	Manures—12-15 cart loads super digest compost Fertilizers—188 Kg. Ammonium Sulphate+250 Kg. single super phosphate	Fert. News. 6(12) : 93

—Not mentioned

Considerable investment is therefore necessary for the spread of agricultural education. At present best stream of students go for engineering, medicine, civil service and business. Only those who can not compete for these institutions take to agricultural profession. Service conditions in agriculture are poorer in comparison with other professions. This reflects the attitude of society to agriculture.

To built up an economic democracy, people must have facts. I have tried to summarise the facts that the Agricultural Scientists with their long and honourable never ending pursuits have gathered and what great frontiers are to be explored. These facts and the onward surge of science and technology in farming combined with the skill and sweat of the farmer and the youth of the country will push forward our agricultural efficiency. Thus the miracle of production of abundance of food can be achieved and the living standards in the countryside can be raised above subsistence level. We will not only meet the demand of our growing population but can feed other people. India is determined to defend democracy with her broader planning and more effective administration. Our efforts, policies and programme to be rooted to our soil and with our native tradition. Established attitudes and patterns of thought have much to do with accepting change and accommodating new factors. We are creature of customs rather than reason. Educational processes and procedures must be basic part of our effort. We should avoid rashness on one hand and delay on the other.

Jai Hind.

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Scientific Policy Resolution

New Delhi, the 4th March 1958/13th Phalgun, 1879

No.131/CF/57. - The key to national prosperity, apart from the spirit of the people, lies, in the modern age, in the effective combination of the three factors, technology, raw materials and capital, of which the first is perhaps the most important, since the creation and adoption of new scientific techniques can, in fact, make up for a deficiency in natural resources, and reduce the demands on capital. But technology can only grow out of the study of science and its applications.

2. The dominating feature of the contemporary world is the intense cultivation of science on a large scale, and its application to meet a country's requirements. It is this, which, for the first time in man's history, has given to the common man in countries advanced in science, a standard of living and social and cultural amenities, which were once confined to a very small privileged minority of the population. Science has led to the growth and diffusion of culture to an extent never possible before. It has not only radically altered man's material environment, but, what is of still deeper significance, it has provided new tools of thought and has extended man's mental horizon. It has thus influenced even the basic values of life, and given to civilization a new vitality and a new dynamism.

3. It is only through the scientific approach and method and the use of scientific knowledge that reasonable material and cultural amenities and services can be provided for every member of the community, and it is out of a recognition of this possibility that the idea of a welfare state has grown. It is characteristic of the present world that the progress towards the practical realisation of a Welfare State differs widely from country to country in direct relation to the extent of industrialisation and the effort and resources applied in the pursuit of science.

4. The wealth and prosperity of a nation depend on the effective utilisation of its human and material resources through industrialisation. The use of human material for industrialisation demands its education in science and training in technical skills. Industry opens up possibilities of greater fulfilment for the individual. India's enormous resources of manpower can only become an asset in the modern world when trained and educated.

5. Science and technology can make up for deficiencies in raw materials by providing substitutes, or, indeed, by providing skills which can be exported in return for raw materials. In industrialising a country, a heavy price has to be paid in importing science and technology in the form of plant and machinery, highly paid personnel and technical consultants. An early and large scale development of science and technology in the country could therefore greatly reduce the drain on capital during the early and critical stages of industrialisation.

6. Science has developed at an ever-increasing pace since the beginning of the century, so that the gap between the advanced and backward countries has widened more and more. It is only by adopting the most vigorous measures