

**Prof M S Swaminathan
International Reports**

1963 - 92

M S Swaminathan Research Foundation
3rd Cross Road, Institutional Area
Taramani, Chennai - 600113

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1963-92 – International Reports

1. Report on the Visit to Sweden and Netherlands-1963
2. Report on the Visit to Vienna-1970.
3. Report on the Visits to Argentina, Colombia and Mexico-1970.
4. Report on the Visit to Rome-1971.
5. Report on the visit to Washington, DC, 1973
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7. Report on the Visits to Thailand, Kampuchea, Vietnam, Russia and Germany-1987.
8. Contribution of Biotechnology to Sustainable Development within the Framework of the United Nations System, 4 February 1992

Report on the Visits to Sweden and
Netherlands during 1963

By

M. S. Swaminathan
Indian Agricultural Research Institute
New Delhi.

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THE SECOND INTERNATIONAL WHEAT GENETICS
SYMPOSIUM, LUND.

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The recent progress in wheat genetics was surveyed at the Second International Wheat Genetics Symposium held at the Genetics Institute, University of Lund, Sweden, from August 19-24, 1963. There were 8 sessions in all dealing with quality, plant breeding methods, disease resistance, taxonomy and phylogeny, amphiploids, aneuploidy and cytogenetic structure as applied to wheat. The speakers in the first seven sessions had all been chosen by an International Organizing Committee and there were no contributed papers in these sessions. From the papers offered voluntarily by different contributors ten were chosen for oral presentation at the last session. There was a business meeting on August 24, 1963, to decide upon the venue and date for the next International Wheat Genetics Symposium. It was decided to hold the next Symposium in Australia just before the 12th International Congress of Genetics which is scheduled to be held in Japan in 1968. A new International Wheat Research Co-ordination Committee comprising Prof. J. Mac Key of Sweden (Chairman), Dr. E.R. Sears (United States), Dr. D.R. Knott (Canada), Dr. R. Riley (U.K.), Dr. A.T. Pugsley (Australia), Dr. T. Matsumura (Japan) and Dr. M.S. Swaminathan (India) was constituted to plan and organise the next International Wheat Genetics Symposium.

There were 201 participants at the Symposium drawn from 45 countries. Dr. B.C. Jenkins of Canada acted as the General Chairman of the Symposium. In addition to the Scientific discussions, excursions had been organised to see the cereal breeding work in progress at Weibullsholm Plant Breeding Institute, Landskrona and the Swedish Seed Association, Svalof. Opportunities were provided to hold discussions with the research workers at the Institute of Genetics, Lund, on problems in fundamental genetics. There was adequate time both for formal and informal discussions and the Swedish hosts headed by the dynamic organising Secretary, Prof. J. Mac Key, left nothing to be desired in the way of catering to the intellectual needs as well as physical comforts of the participants. I give below a summary of the important findings reported at the Symposium.

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1. Wheat Quality:

In this session there were three invited papers dealing with recent research on the estimation of protein quality in wheat in relation to baking and milling properties. Dr. F.J.R. Hird of Australia dealt with frictional changes brought about by changing disulphide bonds. He stressed the fact that the introduction of the aleurone layer in milling will harm the dough. Electro-phoretic analysis of protein structure has revealed that many Australian wheats differ in the presence or absence of certain bands as well as in the intensity of the different bands. Dr. O. Hall of Sweden also presented evidence on the usefulness of electrophoretic analysis of proteins in relation to the determination of quality. This technique is of great value in genetic analysis and there is evidence to suggest that T. durum has duplications of certain bands seen in aestivum varieties. Dr. E.A. Favret of Argentina showed that chromosome 5D of wheat carries genes for gluten strength. Thus, the D genome seems to contribute towards quality.

2. Plant Breeding Methods in Wheat:

Dr. C.F. Konzak of U.S.A. outlined the results of mutation breeding in wheat. He showed that through the use of chemical mutagens a wide spectrum of mutations can be obtained. In this way the chances of picking up a desirable mutation can be enhanced. He confirmed the findings made at the Indian Agricultural Research Institute that awned mutants in an awnless wheat can yield 10-15 per cent more than the parent strain. Mutations for quality, both deleterious and beneficial, can be obtained. Mutations conferring straw stiffness are frequent in the progenies of varieties treated with ethyl-methane-sulphonate. Dr. R.E. Scossiroli of Italy dealt with induced mutations in characters governed by many genes. He pointed out that while mean values for a quantitative trait are usually adversely affected in irradiated populations the variance is much higher. Scope hence exists for selection of some superior genotypes. The genetic component of variance is much higher in the irradiated population. Also, the environmental variance is increased thereby indicating that the interaction with the environment is greater.

Dr. S. Borojevic of Yugoslavia dealt with the estimation of combining ability in wheat crosses.

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He observed transgressive segregations for height and earliness in crosses involving varieties drawn from different geographic regions. Under the conditions in which wheat grows in Yugoslavia earliness could be used as an index of yield and heading date was found to be a good index of earliness. He, however, stressed that it is difficult to assess combining ability from any one criterion. Dr. J.W. Schmidt outlined the experience of American workers in the field of hybrid wheat production. Derivatives of T. timopheevi provided both male sterility and fertility restorer factors. The inheritance of fertility restorers is very complex. The extent of heterosis has been found to be about 12 per cent. There are several problems relating to seed production and quality which have to be overcome before hybrid wheat can become a practical proposition.

3. Disease Resistance in Wheat:

One In this session Dr. R.C.F. Macer of U.K. dealt with the genetical analysis of resistance to stripe rust (Puccinia striiformis) in wheat. Resistance is generally dominant and only one gene is involved in most cases with reference to one physiologic race. The heterozygotes usually show an intermediate pustule type. Monosomic analysis of a cross between Chinese Spring and Red Bobs for race 2B revealed that chromosome 2A carried gene Yr₁ in the long arm. The genetic constitution of different varieties with regard to resistance to stripe rust is given in Table 1.

Table 1.

Genotype of different varieties for stripe rust resistance

Variety	Physiologic race				
	2B	5	8	8B	27/53
Chinese 166	Yr ₁	Yr ₁	Yr ₁	Yr ₁	-
Heine VII	Yr ₂	Yr ₂	Yr ₂	-	Yr ₂
Minister	Yr ₃	-	-	-	-
<u>T. spelta</u>	Yr ₅	Yr ₅	Yr ₅	Yr ₅	Yr ₅
Peko	Yr ₆	-	-	Yr ₆	-
Thatcher	Yr ₇			Yr ₇	

Contd...p/4.

Dr. R.C. Anderson of Canada dealt with the inheritance of resistance to leaf rust in wheat varieties. Thatcher has one major gene for resistance to race 5 but its effects are modified by other genes. Seedling susceptibility is some times followed by post-seedling resistance; hence the stage of development is important in genetic studies. Several workers have reported complementary genes for resistance but on further analysis such resistance has proved to be due to the two varieties used in the cross possessing resistance to two separate races. Thus, when a mixture of races is used, the two varieties will be individually susceptible but will prove to be resistant in a hybrid combination. Dr. D.R. Knott of Canada described the work on stem rust resistance in wheat. Several different sources of resistance genes have been identified in Triticum and Agropyron. By a remarkable piece of chromosome engineering Dr. Knott succeeded in transferring the Sr_6 gene for stem rust resistance located on chromosome 2D of T. aestivum to T. durum. Chromosome 2D was isolated by back crossing the pentaploid hybrids to T. durum and the transfer of the Sr_6 gene was accomplished through a neutron induced translocation. Thus, not only has a new form of resistance become available in tetraploid wheat but it has also become feasible to study the effect of gene dosage on resistance by crossing durum with aestivum. In serological studies, none of the tests revealed the presence of an antigen specific to the genotype. Hence Flor's views could not be confirmed in wheat. Dr. W.Q. Loegering dealt with the relationship between the host and the pathogen in wheat. In general, similar patterns of major gene effects are visible with reference to resistance to all fungal pathogens. Dr. Loegering proposed the use of the term "aegricorpus" to indicate the infected organism. The host-pathogen-environment reaction conditions the aegricorpus. This concept will be very valuable in explaining the differences in the genetic results obtained by different investigators and phenomena such as reversal of dominance. Dr. Loegering expressed disappointment that the resistance transferred from allied genera has proved to be unstable. Dr. A.T. Pugsley dealt with mildew resistance in wheat. About 30 physiologic races have been isolated in the mildew organism and six different genes have been identified in 17 varieties. The six genes and the names of the varieties in which they were first identified are given in Table 2.

Table 2.

Genes for mildew resistance

Gene symbol.	Variety in which first identified
Ml_1	Thew
Ml_3	Sonora
Ml_u	Ulka
Ml_c	Chul
Ml_a	Asosan
Ml_b	Birdproof

Contd...p/

Dr. E.E. Sebesta of the United States outlined the genetics of resistance to viruses in wheat. In the United States the "Take-all" disease has appeared in an epidemic form during the last few years. The mosaic virus is also important. Derivatives from crosses between Agropyron and Triticum species are promising from the point of view of breeding for resistance. Only one pair of chromosomes in Agropyron controls the local lesion reaction to mosaic virus. Hence, the inter-generic transfer of resistance can be brought about without much associated adverse effects.

4. Wheat taxonomy and phylogeny:

In this session there were papers by Drs. Zohary of Israel, Y. Cauderon of France, E.B. Wagenaar of Canada and J. Mac Key of Sweden. Dr. Zohary pointed out that there must be one pivotal genome common to all tetraploid Triticums and one genome which may get modified. Many of the so-called species did not show clear morphological discontinuity and hence they should be referred to as "species clusters". The possibility of introgression from allied genera may explain the occurrence of several "super genes" in wheat. Miss. Cauderon provided data to show that the chromosomes of Agropyron and Triticum species do not pair with each other, while Dr. Wagenaar showed that chromosomal differences exist within the Triticum timopheevi complex. Dr. Mac Key, who had earlier merged all the hexaploid species of Triticum as sub-species of Triticum aestivum L., now proposed that a similar merger as shown in Table 3 should be adopted with regard to the tetraploids:

Table 3.

Mac Key's scheme of taxonomic classification of species in Triticum

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Somatic Chromosome Number.	Species.	Sub-species.
14	<u>T. monococcum</u>	<u>Monococcum</u> <u>Aegilopoides</u>
28	<u>T. turgidum</u>	<u>Dicoccum</u> <u>Carthlicum</u> <u>Polonicum</u> <u>Turgidum</u>
28	<u>T. timopheevi.</u>	<u>Timopheevi</u> <u>Araraticum</u>
42	<u>T. aestivum</u>	<u>Vulgare</u> <u>Sphaerococcum</u> <u>Compactum</u> <u>Spelta</u> <u>Macha</u> <u>Vavilovi</u>

5. Amphiploids and addition to wheat of characters from related genera:

Prof. A. Muntzing of Sweden presented the data obtained by Prof. Pissrav of the U.S.S.R. and himself in breeding studies with rye-wheat hybrids. Prof. Pissrav finds that the high protein content of rye-wheats can be transferred to soft wheats through hybridisation. Since the D genome of wheat introduces susceptibility to many diseases, he is attempting to replace the D genome with the rye-genome. Prof. Muntzing pointed out that in Sweden very good rye-wheat strains have been evolved by using self-fertile strains of rye. Some of the features of rye-wheat in relation to wheat are given in Table 4.

Table 4.

Characteristics of Rye-wheat strains produced in Sweden.

Character	Rye-wheat	Wheat parent
1000 Kernel weight	58 to 60 gms.	46-50 gms.
Kernel quality (grading value)	9.86	10
Yield (% of wheat)	90 to 98	100
Crude protein content (relative value)	120.6	100

The tendency for pre-germination in rye-wheat is not desirable from the point of view of baking quality and hence attempts are being made to eliminate this character. Rye-wheat shows very good winter hardiness. Dr. B.C. Jenkins of Canada described the various substitutions and additions of rye-chromosomes brought about in wheat. Similarly, Dr. A. Wienhues of Germany described the substitutions of Agropyron pairs for wheat pairs. The question whether an alien pair could be expected to replace only a homoeologous wheat pair with which it has a common evolutionary origin, is still open since the evidence present available is insufficient to clarify this issue. Prof. H. Kihara of Japan described the production of male sterile forms of wheat by transferring wheat nucleus into the cytoplasm of various other species. In certain combinations, such as timopheevi cytoplasm plus durum nucleus, haploids occur frequently. Thus, the interaction between the cytoplasm and the nucleus can be used as another method for the production of haploids.

6. Aneuploidy in wheat genetics:

There were four papers in this session. Owing to its hexaploid constitution, T. aestivum is a difficult material for conventional linkage analysis but Dr. E.R. Sears of the United States demonstrated how this could be accomplished by using telocentric chromosomes. The linkage distance between single major genes and the centromere can be estimated with precision by this method. In this way he has already gathered data on some of the genes located in chromosomes 3B and 6B. The gene for leaf rust resistance introduced from Aegilops umbellulata has been found to be located in a distal segment of chromosome 6B. The usefulness of aneuploid analysis in varieties of bread wheat was demonstrated by Dr. R.I. Larson of Canada with regard to solid stem characters and by Dr. J. Kuspira of Canada with reference to quantitative characters like yield. Aneuploid analysis has been difficult in tetraploid wheats because aneuploids do not survive so readily in them. However, Dr. Noronha Wagner of Portugal working with T. durum was able to obtain nullisomic-tetrasomic combinations for some chromosomes. From these studies it is clear that there is considerable gene homology between the A and B genomes. From a lantern slide shown by Dr. Wagner, I pointed out that the ear of nulli 7B-tetra 7A has sphearococcoid characters and glume discolouration. This suggests that the sphearococcoid character could well arise through duplication of a gene present in chromosome 7A together with the absence of a gene in chromosome 7B.

7. Cytogenetic structure of Wheat:

Dr. R. Riley of U.K. provided data in confirmation of the hypothesis that homoeologous meiotic pairing and recombination occur when the effect of the multivalent suppressor gene in chromosome 5B is removed. The pairing taking place in the absence of the gene in chromosome 5B is largely between the homoeologous chromosomes in the different genomes. Dr. Riley postulated that the multivalent suppressor gene should have evolved as a mutation after the tetraploid wheats arose. He also suggested that Aegilops mutica is as likely as Aegilops speltoides to have been the B genome donor. The fact that the removal of 5B promotes allosyndetic pairing can be exploited in wheat breeding. Another interesting point made by Dr. Riley

Contd.....p/8.

is that a high frequency of polyhaploids occur in the progenies of plants monosomic for chromosome 1A. Dr. M. Okamoto of Japan provided experimental evidence to suggest that mutations affecting pairing can occur in wheat. Dr. J.G.T. Hermesen of the Netherlands showed that Triticum macha carries on different chromosomes one gene for necrosis and another gene for chlorosis.

My paper entitled "Mutational analysis in the hexaploid wheat complex" was also included in this session. I showed how the free threshing gene Q evolved through a series of tandem repeats starting with the initial Q present in einkorn wheat. In einkorn, Q ensures organised flower morphogenesis. In the presence of Q several lethal and semi-lethal factors can be present in cultivated wheats. I suggested that the existence of such "harmful genes" may not be due to "genetic inertia" facilitated by polyploidy but may have some bearing on fitness and vigour. The paper dealt with the probable evolutionary history of the Q, C and S loci in wheat.

8. Contributed Papers:

A series of papers were presented by Russian workers indicating how Spring wheat can be converted into winter wheat through adaptation. Vernalization at 2-3°C has been found to be effective in increasing protein content. Two papers of interest in this session were one dealing with adaptation of varieties by Dr. K.W. Finlay of Australia and another by Dr. R.M. Caldwell of U.S.A. on the genetics of resistance to Hessian Fly (*Phytophaga destructor*). Three genes have been found for resistance to Hessian fly and four races (A, B, C and D) have so far been isolated in the flies. Thus, the old view that physiologic specialisation may not occur in insects seems to be incorrect.

The proceedings of the Second International Wheat Genetics Symposium will be published as a supplement to "Hereditas". When published, this will be a compilation of great value to the geneticists and breeders working on wheat.

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II. THE FIRST INTERNATIONAL BARLEY GENETICS SYMPOSIUM, WAGENINGEN

This symposium was held from August 26-30, 1963 at Wageningen, the Netherlands. There were several Sessions dealing with the origin, genetics, breeding and quality of barley. The papers were exceedingly interesting, and of a very high standard. There was also a visit to a few Breweries. I was asked to serve on a Committee constituted to discuss the possibilities of International Co-operation in the field of Barley Research. My suggestion that a composite bulk of all the tetraploid barley varieties produced in different countries/so that a maximum genotypic diversity can be generated for fertility characters was welcomed. Dr. H. Gaul of Germany was assigned this work.

The other measures for coordinating barley research which were decided upon are as follows:

i. Genetic Marker Stocks - Dr. D.W. Robertson

It is proposed that Dr. Robertson maintain the genetic seed stocks and serve as overall coordinator for genetic linkage studies.

Individuals responsible for the coordination are as follows:

Overall coordinator - Dr. D.W. Robertson

Chromosome 1 coordinator - Dr. R.G. Shands.

2 - Dr. G.W.R. Walker.

3 - Dr. R. Takahashi

4 - Dr. D.W. Robertson

5 - Dr. Henry Shands

6 - Dr. C.R. Burnham (?)

7 - Dr. Arne Hagberg (?)

Procedure for seed stocks:

Seed samples of all new described mutants should be sent to Dr. D.W. Robertson to make them available to other workers. Include:

- a. variety in which obtained
- b. description of mutant
- c. origin of mutant - spontaneous or induced (if induced, give agent)
- d. any genetic data obtained.

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Dr. Robertson and his committee on assigning gene symbols will then assign the character a symbol.

In order to provide worldwide coordination for genetic studies other persons have been assigned responsibility for individual chromosomes. It is desirable that individuals conducting gene studies inform the coordinators of their projects. Those interested in initiating a particular genetic study are invited to inquire of the various coordinators whether their proposed project is being carried out by other investigators as well as inform the coordinators of the proposed investigation. Coordinators should also be sent data or information relative to their respective chromosomes.

This is a concept where coordinators will act as a clearing house and data will be handled confidentially. Research workers will be referred to those doing work on the particular project rather than be given the information by the coordinator. Properly used, (i.e. workers sending information to, and requesting information from) this coordinator arrangement should prevent duplicative efforts and provide more coordinated research.

ii) Translocation and tertiary trisomic stocks -
Dr. R.T. Ramage.

It is proposed that Dr. Ramage maintain the translocation and tertiary trisomic stocks and -serve as coordinator for translocation studies.

Procedure:

Seed samples of all new translocations should be sent to Dr. Ramage with the following information:

1. originator's designation (number, etc)
2. cytological data on breakpoints, if available
3. variety or hybrid in which induced
4. methods of induction (mutagenic agent).
5. authority
6. chromosomes involved
7. linkage data, if available, in the following form:

Cross	Type of data	form:				Total	P. ±	S.E.
		a	b	c	d			
T2-4 axor	F2	e 33	f 17	g 33	h 17		50 ±	?

After information and seed stocks have been received the translocation stock will be assigned a letter designation.

iii) Trisomic and Aneuploid Stocks - Dr. T. Tsuchiya

It is proposed that Dr. Tsuchiya maintain these stocks and serve as coordinator for aneuploid studies.

Procedure:

Seed samples of all new aneuploids should be sent to Dr. Tsuchiya with the following information:

- a. variety in which obtained
- b. cytology data if available
- c. methods of induction
- d. authority
- e. chromosome(s) involved.
- f. linkage data, if available, giving class numbers.

iv) Inversion stocks - Dr. R. A. Nilan.

It is proposed that Dr. Nilan maintain and serve as coordinator for inversion studies.

Procedure:

Seed samples of all new inversion stocks should be sent to Dr. Nilan with the following information:

- a. variety
- b. origin (induced or spontaneous)
- c. authority
- d. chromosomes involved.

v) Disease Resistance Stocks - Dr. J.G. Moseman

It is proposed that Dr. Moseman maintain the disease resistance stocks:

Procedure:

Seed samples of all resistance sources (except those with U.S.D.A. "C.I.* Numbers) should be sent to Dr. J.G. Moseman along with the following information:

- a. disease concerned (Latin name).
- b. name of variety.
 - i) natural resistance, or
 - ii) mutant
 - 1) spontaneous, or
 - 2) induced
- c. number and designations of cultures used
- d. method and technique of testing material
- e. authority.

vi) Barley literature - Dr. R. A. Nilan

It is proposed that Dr. Nilan maintain the comprehensive summary of barley literature. Dr. Nilan should be sent reprints of all publications dealing with barley. The current summary, "Cytology and Genetics of Barley, 1951 - 1962" is in press and will soon be published by the Washington State University Press.

III. THE XIth INTERNATIONAL CONGRESS OF GENETICS, THE HAGUE

The XIth International Congress of Genetics was held at the Hague from September 2-10, 1963. Prof. E. Hadorn of Switzerland was the President of the Congress and I was one of the Vice Presidents, this being the first time for an Indian Scientist to hold this position. At the opening function the highest title of the Netherlands was conferred upon Prof. M. J. Sirks of the University of Groningen by the Queen of the Netherlands. The Congress was extremely well organised and there were many interesting Symposia and Sessions. I presented the following two papers at the Congress:

1. Induced Mutations at the "Q" locus in relation to the phylogeny of hexaploid Triticum species.
2. Incidence of mutations in D. melanogaster fed on irradiated medium.

I also acted as the Chairman of the Session dealing with Plant Genetics held on September 9, 1963. I had many discussions with the leading Geneticists of the world and the Congress proved to be a stimulating experience. I was invited by the Queen of the Netherlands as well as the Ambassadors of the United States and U.S.S.R. for Dinner. It was a great joy to see the amount of interest which the Governments of Countries in Europe and United States take in Scientists.

IV. LECTURES AT THE AGRICULTURAL UNIVERSITY, WAGENINGEN.

I gave a series of four lectures at the Agricultural University at Wageningen. These had been widely publicised and I enclose a copy of the Notice issued by the University.

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There was a very enlightened audience at all the meetings and every lecture was followed by detailed discussions. The Rector Magnificus of the Agricultural University expressed a keen desire to have close relationships with Indian Agricultural Scientists. The Dutch have had extensive experience of tropical agriculture and they hoped that the Indian Embassy at the Hague will take some interest in establishing contacts with Wageningen.

CONCLUSIONS

The participation in these International Symposia was of great value in learning the trends of thought and experimentation currently underway in foreign countries. The contacts established have helped in obtaining very valuable genetic material. I enclose as an example a copy of a letter received from Dr. Williams of North Dakota.

ACKNOWLEDGEMENTS

I am grateful to the organisers of the International Wheat and Barley Genetics Symposia and the International Congress of Genetics as well as the authorities of the Agricultural University, Wageningen, for inviting me to deliver these lectures and meeting all my expenses. My sincere thanks are also due to the Government of India and to Dr. B.P. Pal, Director, Indian Agricultural Research Institute for permitting me to accept these invitations and experience a great intellectual treat.

Enc: ref.to.

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Copy:

United States Deptt. of Agriculture
Agricultural Res. Service
Crops Research Division
October 18, 1963.

Stated University Station,
Fargo, North Dakota.

AIR MAIL

Dr. M. S. Swaminathan,
Divn. of Botany, I. A. R. I.,
New Delhi-12.

Dear Dr. Swaminathan,

You mentioned at the Wheat Genetics Symposium in Lund that you would like to have seed of stem rust resistant durums. I have sent packets of seed of 14 varieties to Dr. J. C. Craddock, Beltsville, Maryland, who will handle inspection of the seed and will forward the seed to you by air. The varieties I have sent are listed as follows:

- | | |
|----------------|-------------------|
| 1) Wells | 8) C.I. 7805 |
| 2) Lakota | 9) ST. 464 |
| 3) Yuma | 10) C.I. 3255 |
| 4) Ramsey | 11) P.I. 94701 |
| 5) Langdon | 12) P.I. 192168 |
| 6) Golden Ball | 13) C.I. 8155 |
| 7) P.I. 192179 | 14) Khapli emmer. |

The first five varieties were developed at North Dakota, but the remaining ones were selected from the World Collection of Wheat. These varieties are resistant or partially resistant to the races of rust prevalent in the durum growing area of North America. Khapli emmer was the main source of resistance for Wells, Lakota, Langdon and Yuma. None of these 4 varieties possess all of the Khapli resistance genes. P.I. 94701 was the source of resistance for Ramsey. Golden Ball and C.I. 3255 probably have the same major gene for resistance as P.I. 94701. ST. 464, P.I. 192179, C.I. 8155 and C.I. 7805 are similar in resistance and each have at least 2 major genes which provide us with a high degree of resistance. P.I. 192168 probably has a resistance gene different from any of those represented in the other 13 varieties. I would be greatly interested in hearing from you how these varieties perform in your area, especially with respect to resistance to stem rust.

It was a great pleasure for me to meet you and talk with you at the meetings. I hope the seed will reach you in time for planting.

Sincerely yours,

Sd/- Norman D. Williams,
Geneticist.

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Landbouwhogeschool Wageningen

DR. M.S. SWAMINATHAN

Head, Division of Botany, Indian Agricultural Research Institute, New Delhi, India

zal in september 1963 in de collegezaal van het

Laboratorium voor Erfelijkheidsleer, Gen. Foulkesweg 53, de volgende voordrachten

houden :

1. Woensdag 11 sept., 16.00 uur precies :
Macro-mutations and sub-specific differentiation in Triticum.
2. Donderdag 12 sept., 16.00 uur precies :
Mutation breeding in some polyploid crop plants.
3. Vrijdag 13 sept., 16.00 uur precies:
Indirect effects of radiations with reference to the use of radiation in food preservation.
4. Maandag 16, sept., 11.00 uur precies:
Experimental manipulation of embryo growth in some incompatible interspecific crosses.

BELANGATELLENDEN ZIJN HARTELIJK WELKOM

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Landbouwhogeschool Wageningen

DR. M. S. SWAMINATHAN

Head, Division of Botany, Indian Agricultural Research Institute, New Delhi, India

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interspecific crosses.

BELANGATELLENDEN ZIJN HARTELIJK WELKOM

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Proof mss
Report on the visit
Vienna - 1970

FAO/IAEA Symposium - Plant Protein Resources: Their
Improvement through the Application of Nuclear Techniques

I attended the Symposium from June 9th to 12th, 1970. On the afternoon of 12th June and on the 13th June, I attended the Research Coordination meeting convened by the Joint Division of FAO and IAEA to draw up the future lines of work in this field. I was asked to be the Chairman of the Session on "Determining nutritional value of plant protein" and I was also the Chairman of the Drafting Committee set up for drawing up the recommendations of the coordination group. I presented a paper on "The Choice of Strategy for the Genetic Upgrading of Protein Properties in Cereals, Millets and Pulses" (copy enclosed). Dr. A.K. Kaul from the I.A.R.I. presented a paper on "Microscopic and Other Dye Binding Techniques of Screening for Proteins in Cereals" (copy enclosed). Some of the main points made at the Symposium are as follows:

1. New high protein and high lysine varieties: Dr. A. Hagberg from Svalof, Sweden, reported that a barley strain (CI 3947) named "Hiproly" has proved to be very useful in breeding barley varieties with high protein and high lysine because of the fact that the shrunken nature of the seed in Hiproly is not linked with the gene for high lysine. Hiproly was identified in a collection of barley from Ethiopia. From the same collection, another line (CI 4362) has been found containing high protein, but normal amount of lysine. Dr. H. Gaul of Germany reported that auto-tetraploid barley has a protein content of about 18% in contrast to about 14% in the diploid. Dr. V.A. Johnson from the United States announced that a variety of wheat obtained from India (probably from Nepal-PI 176217) is rich in both protein and lysine. Dr. Dumonovic from Yugoslavia found a negative correlation between the weight of grains and yield. In barley also, a negative correlation tended to occur between protein content and yield. However, several workers reported that by appropriate fertilizer application a satisfactory balance between yield and protein content can be achieved.

2. High protein and high lysine crop species: There was considerable interest in the paper from the I.A.R.I. which I had presented in which we had shown that some minor millets like Panicum miliaceum have both high protein and lysine. It was felt that the I.A.R.I. work on producing high yielding varieties of such millets would make a very important contribution to enriching protein resources. Papers were presented about the improvement of the protein properties and yield of soybean and sunflower. Dr. Smutkupt of Thailand reported that the soybean varieties SJ-1, SJ-2 and SJ-3 are early as well as rich in protein. The protein of sunflower would gain in value, if chlorogenic acid can be eliminated.

3. Availability of lysine: Although several crop species and varieties may have satisfactory content of lysine, its availability is poor due to many reasons such as the presence of fibre in the seed. Generally

only 75% of the lysine present in cereals is available. It was, therefore, felt that increasing the availability of protein and improving digestibility should be given adequate attention.

4. Techniques: Among the various techniques available now, the dye binding capacity method and the microscopic section scoring procedure reported by Drs. Kaul and Munck were considered to be the most useful ones at present for rapid screening of material. Other techniques such as micro-biological methods, neutron activation, double isotopic labelling and X-ray spectrometry were also discussed.

5. Biological value and Net Protein Utilization: Considerable stress was laid on the assessment of these properties since mere data concerning protein and lysine content would otherwise be misleading. True digestibility is influenced by several characters like the morphology and anatomy of seeds, the nature of carbohydrates, fibre content etc. Blood urea content could be used in animals to assess protein quality provided this is done carefully. In vitro enzymic procedures can also be used for assessing the biological value of proteins. The enzymes that are useful for this purpose are: Pepsin, Pancreatin, Trypsin, Erepsin, Pronase and Papain.

Prof. E.O. Eggum of Denmark summarised the current methods of evaluating the nutritive value of protein in grains. He presented data which showed that the wheat variety Sharbati Sonora developed in India has the highest biological value and net protein utilization among all the wheat varieties studied by him in Denmark, as per his data given below:

	Sonora-64 (Mexican)	Super-X (Mexican)	Inia (Mexican)	Average Danish Wheat	Sharbati Sonora (Indian)
Biological value:	52.0	49.0	49.4	59.0	60.5
Net Protein Utilization:	48.4	49.1	44.3	52.9	53.9

6. Production control and Agronomic Enrichment of Quality: The importance of studying protein properties at all stages from the time the crop is harvested to the time it is consumed was stressed. In several countries there is a considerable deterioration in quality during storage. The application of nitrogen during grain development increases protein content but it would be worthwhile for the farmer to adopt such a practice only if there is a premium for protein content in pricing policy. The application of some herbicides like Simazine increases accumulation of nitrate reductase in barley and thereby promotes the accumulation of protein.

7. Importance of protein improvement in developing countries: Since it is now reasonably well established that protein malnutrition in the first few years of a child's life leads to a fewer number of cells in the brain, the urgent necessity for the genetic upgrading of protein quantity and quality in food grains is obvious. UNDP (Special Fund) has given over 1.5 million dollars to the International Maize &

Wheat Improvement Centre in Mexico for intensifying this work. The Government of the Federal Republic of Germany has offered nearly 2 million dollars to the Joint FAO/IAEA Division on the application of atomic energy in agriculture for promoting research in this field during the next five years.

8. General Conclusions:

The general conclusions arrived at the coordination meeting are as follows:

a) The dimensions of the world protein gap are both quantitative and qualitative in character. In many developing countries, the primary nutrition problem relates to inadequate calorie intake, either due to low agricultural productivity or low purchasing power or both. Particularly in such areas, sections of the community such as young children and pregnant mothers may suffer from protein malnutrition. While technological approaches such as lysine fortification, production of protein from petroleum and single cells and manufacture of fish protein concentrates have all some merits, a major dent on the protein malnutrition problem can be made in the near future only if the basic foodgrains can be upgraded in nutritive quality, so that the nutrition of the economically handicapped sections of the population can be improved without any special educational effort or added expense. It is in this context that the genetic improvement of the quantity and quality of protein in the major food crops of the world assumes great significance.

b) The specific approach towards protein improvement will vary from crop to crop and region to region. Therefore, for each crop and situation, the precise problem will have to be identified and the scientific approach towards finding a solution developed. In many cereals and pulses, elevating the content of the limiting amino acid rather than increasing protein content per se has to be the primary aim. In several millets and cereals, enhancement of the net protein utilization is unsatisfactory not only due to the poor amino acid balance but also due to low digestibility. There are several grain legumes like soybean, chick pea, etc. which have a high protein content but whose productivity can be improved by developing better plant types. Improving photosynthetic ability, lodging-resistance and disease resistance all need attention in such crops. The removal of toxic principles can render several legumes which are highly resistant to drought such as Lathyrus sativus, excellent food material.

c) The contribution of plant breeding towards improving protein supply could be broadly grouped into the following major approaches:

- i) Development of high yielding-cum-high quality strains of cereals, millets and tuber crops.
- ii) Improving the yield potential of grain legumes and increasing the content of Methionine in them.
- iii) Development of better quality vegetables and fruits.

iv) Development of high yielding-cum-high quality fodder and feed crops which would be substitutes for concentrates so as to improve animal productivity.

v) Development of new protein-rich crops like Triticale, Gossypol-free cotton etc.

d) In research relating to the improvement of protein properties, there is need for an understanding of the basic biochemical processes concerning storage protein synthesis so that human needs can be harmonised with the physiological needs of the growing embryo for which proteins are synthesised in the seed. Also, the problems have to be looked at in their totality, starting with the innate characteristics of the seed upto its consumption.

sb.

1970

1. ARGENTINA

I participated in the Latin American Study Group meeting on Induced Mutation and Plant Improvement held at Buenos Aires from 16th to the 20th November, 1970. I attended a meeting of the Coordination Committee of FAO/IAEA on the Use of Induced Mutations on November 21st, 1970. The Symposium was organised by the Instituto Nacional De Tecnologia Agropecuaria (I.N.T.A.) which is an organization similar to the Indian Council of Agricultural Research. Some of the important scientific findings reported at the Symposium are summarised below:

1. Breeding for higher yields

On the basis of an analysis of the advances in yield made in recent years in rice and wheat, it has become clear that there may be little scope for making further advances in yield through merely a reapportionment of the total biological yield between grain and straw. What is therefore important hereafter is the construction of simulation models which can help to design more efficient plants. The present architecture of cultivated plants requires careful study and examination from the viewpoint of their suitability for high productivity. For example, are tassels necessary in all maize plants or will it be better to permit the formation of a tassel only one in five plants. In the construction of efficient crop production models, the following considerations ought to be kept in view:

- (a) The efficiency of energy capture in photosynthesis
- (b) The loss of energy through respiration associated with cellular maintenance and growth
- (c) The partitioning of the accumulated energy pool among various parts of the standing crop, some of which form the economically useful yield

The importance of photosynthetic capability was emphasised at the Symposium. There are two basic groups of plants under cultivation:

- (a) A high capacity group including maize, sugarcane, jowar, other tropical grasses and some dicotyledons such as Amaranthus and certain Atriplex spp.
- (b) A lower capacity group including wheat, temperate grasses, cotton, sunflower, sugar beet and pulses.

These two groups of crop plants have different characteristics as shown in Tables 1 and 1(a).

Table 1

Photosynthetic systems in crop plants

Character	Low capacity species	High capacity species
Net photosynthetic rate in full sun, mg Co ₂ day ⁻² hour ⁻¹	25-45	45-60
Carbon path	Calvin cycle, fix Co ₂ with C ₃ acid	Hatch-Slack path, fix Co ₂ with C ₄ acid
Co ₂ compensation point ppm v/v Co ₂	> 40	< 10
Increase in net photosynthetic rate in low oxygen	Yes	No

Table 1(a)

Maize populations from which S_1 families were evaluated
for tryptophane, 1969

Identity	No. of families analyzed
Bolita	38
Cacahuacintle	52*
Celaya II	300
Comiteco	30*
Conico	43*
Chapalote	30*
Puebla Gpo IA	200*
Harinoso de Ocho	44*
Nal Tel	53
Maize Dulce	88*
Pepitilla	30*
Pinto Salvatori	102*
Reventador	37
Tabloncillo	30*
Comp E:	83*
Racial crosses	168
Caribbean Composite	500
Salvadoreno	30
Santa Catalina	302
Colombia - Ecuador collections	30**

* Source of potential new high lysine mutants.

** Analyzed as collections not as S_1 families.

It is now clear that these systems are under genetic control and that they can be probably modified through mutations.

There was much interest, therefore, in the paper I presented on "The mutational reconstruction of crop ideotypes".

The problem of diseases associated with high yielding varieties was discussed at length. The lessons from the attack of the maize crop in the United States by Helminthosporium maidis was discussed and it was concluded that it would be imprudent to base hybrid vigour programmes on a single source of male sterility. It was, therefore, felt that steps should be taken to diversify the sources of male sterility as well as resistance. The appearance of

coffee rust in Brazil and its possible spread to other countries like Colombia were also discussed and it was felt that all the available coffee collections should be screened immediately for resistance. Coffee rust was first noticed in Brazil on January 27, 1970 in the States of Bahia, Minas, Geras and Espiratu Santo.

The prospects for the improvement of grain legumes were discussed at length. It was pointed out that gene banks consisting of over two thousand genotypes have been established in Colombia and Mexico in the following crops:

1. Phaseolus vulgaris
2. Phaseolus lunatus
3. Vigna sinensis

Over ten thousand lines of maize have been preserved by Dr. Brieger in Brazil. Studies on hybrid rice conducted in Peru have shown that some of the hybrids give nearly 80 per cent more yield than the best commercial variety. In potato, crosses between Solanum tuberosum and Solanum andigena have given a tremendous increase in yield. The general question whether there should be more emphasis on hybrids or composites was discussed and it was generally felt that composites might be better for being grown over wide environments as well as for enabling farmers to keep their own seeds.

The problems in the improvement of perennial plants like banana and coconut were discussed and it was felt that in the case of coconut, mutation breeding might offer some scope if good genotypes can be multiplied by cell cultures. The possibility of achieving specific alterations in mutation spectrum were discussed and the following four approaches were regarded as promising:

- (a) alteration of pre and post-mutational sieves
- (b) treating selectively active and non-active genes
- (c) manipulating nuclear and extra nuclear genes
- (d) achieving genetic transformation.

The approach developed at the Indian Agricultural Research Institute for treating genes during different stages of the 'S' phase of DNA synthesis was considered to be the most effective one available at present.

II. COLOMBIA

I visited the International Centre for Research on Tropical Agriculture (CIAT) located at Cali, Colombia. This Centre is organized as a non-profit corporation in Colombia. It is under the direction of a Board of Trustees and an Executive Committee of the Board.

The principal financial sponsors at present are the Ford Foundation, the W.K. Kellogg Foundation, and the Rockefeller Foundation. The Government of Colombia, by purchasing the headquarters site and making it available at a nominal rent, contributes substantially to the support of CIAT.

Within Colombia, the Instituto Colombiano Agropecuario (ICA), a body similar to I.C.A.R., greatly facilitates the activities of CIAT by sharing its research and training facilities, participating in cooperative projects, and providing personnel for consultation and work in specific projects. Other close cooperators in Colombia include the National University and the University of the Valley.

While central headquarters are being constructed on the 500 hectare site near Palmira, Colombia, the CIAT staff is housed with cooperating institutions and in leased facilities in Cali.

Dr. U.J. Grant, who was formerly with the Indian Agriculture Programme of the Rockefeller Foundation, is the Director of this International Institute. The following are some of the main points of interest to India from the work of this Institute:

1. Occurrence of strains of Tapioca with as much as 8% protein

One particular variety called "Llanera" has a protein content ranging from 6 to 8% and it has also a high yield potential (about 70 tonnes per hectare) together with good cooking quality. One kg of Llanera will give 25 gms of protein while one kg of a normally cultivated variety will give only 5 gms. I arranged for the supply of propagating material of this and other promising varieties through the I.A.R.I. Plant Introduction Division.

2. Development of two double cross hybrids of maize containing the opaque-2 gene

These hybrids named ICA-H208 and ICA-H255 have given in feeding trials with swine 12 times more weight than the normal maize. Both the hybrids belong to the flint type and have been released for cultivation by ICA.

3. Use of agricultural by-products in feeding cattle

Very interesting work has been done on the use of various agricultural-by-products as animal feeds. Some of the rations standardized at CIAT are given in Tables 2 and 3. It would be useful to have collaboration between CIAT and IVRI and NDRI in such research.

4. Cross breeding in cattle

Crosses between local breeds referred to as Criollo and Zebu has given excellent results. Some of the Criollo breeds are the products of selection under tropical conditions from European breeds such as Andalucia introduced by the Spaniards in the 16th and 17th centuries. It would be worthwhile for us to get the Criollo breeds such as (a) San Martinero, (b) Romosinuano, (c) Costenoconcuerno and (d) Blanco Orejuneiro.

I attended on November 26th the Latin American Congress of Fitotecnica held at Bogota and delivered a special lecture on "Multiple Crop Cafeterias for irrigated and dry areas". This lecture was largely attended and there was very great interest in the concept of multiple cropping and in the new technology for dry land farming developed in India.

III. MEXICO

I reached Mexico on the 27th November and visited the laboratories and fields of the International Maize and Wheat Improvement Centre (CIMMYT). Drs. N.E. Borlaug, R. Osler, E.W. Sprague, J. Neiderhauser and other scientists showed me the work being done in wheat, maize and potato in great detail. I also visited the Puebla Project on 29th November and addressed a large gathering of farmers of that region. I was very happy to see four former students of IARI, Drs. George Varughese, V.L. Asnani, S.K. Vasal and Raja Ram, doing excellent work and being held in very great esteem. Some of the points of interest to our work are indicated below:

1. Development of high quality maize composites

A brief description of the different composite populations developed at CIMMYT is given below:

1. Composite K.

The composite is meant for tropical areas and it contains both opaque-2 and floury-2 genes. This composite was formed from opaque-2 and floury-2 conversions in different genetic backgrounds that had undergone varying number of backcrosses to the recurrent parent (Normal parent). The basic materials that were included in the formation of this Composite are Tuxpeno, Cuban flints, Antigua 2 D, Salvadoreno, West Indies semi dent and Eto Blanco.

Table 2

Some practical rations for growing - finishing cattle in feedlot (Kgs/day/animal) ^{a/}

INGREDIENT	Type of Ration									
	A	B	C	D	E	F	G	H	I	J
Safflower meal ^{b/}	4.0	1.0	-	-	-	-	1.90	-	4.50	2.00
Cottonseed meal ^{c/}	-	-	1.5	0.5	2.0	0.9	-	1.90	-	-
Molasses	3.0	3.0	3.0	3.0	4.0	4.0	3.0	3.0	4.0	4.0
Urea	-	0.15	-	0.15	-	0.15	0.15	-	-	-
Cottonseed hulls	2.0	2.0	2.0	2.0	2.0	3.0	2.0	2.0	<u>ad lib</u>	3.0
Corn or sorghum silage	<u>ad lib</u>	<u>ad lib</u>	<u>ad lib</u>	<u>ad lib</u>	<u>ad lib</u>	<u>ad lib</u>	-	-	-	-
Fresh chopped sugarcane	-	-	-	-	-	-	<u>ad lib</u>	<u>ad lib</u>	-	-
Fresh alfaalfa	-	-	-	-	-	-	-	-	-	<u>ad lib</u>
Bone meal (gm/day)	-	50	-	50	-	50	50	50	-	-
Trace mineral premix ^{d/}	-	-	-	-	-	-	-	-	-	-
Vitamin A ^{e/}	-----10.00 IU of Vitamin A palmitate/animal/day									
Salt	<u>ad lib</u>	<u>ad lib</u>	<u>ad lib</u>	<u>ad lib</u>	<u>ad lib</u>	<u>ad lib</u>	<u>ad lib</u>	<u>ad lib</u>	<u>ad lib</u>	<u>ad lib</u>

- a) All rations contain 10.0 to 10.5% crude protein on an air dry basis
- b) Wheat bran can be substituted for safflower meal
- c) Corn cobs, corn stover, chick pea hay, bagasse fines, etc. can be substituted for cottonseed hulls.
- d) CIAT trace mineral premix (see formulation)
- e) No supplementary Vitamin A is needed when green alfaalfa is fed

Formulated by: Ned S. Raun -CIAT

Table 3

CIAT trace mineral premix for ruminants^{a/}

	%	Amount of each element in ppm supplied in the total diet from the trace mineral premix	Requirement in ppm in the total diet
Copper sulfate (Cu)	1.95	5	10
Iron sulfate (Fe)	5.00	10	40
Zinc oxide (Zn) ^{b/}	1.24	10	30
Manganese sulfate (Mn)	3.09	10	25
Cobalt sulfate (Co)	0.20	0.5	0.1-1.0
Potassium iodide (I)	0.07	0.5	0.1-1.0
Wheat bran (vehicle)	88.45	-	-
	100.00		

a) Add at the rate of 0.1% of the total ration. A mixture of 10.0 parts salt, 5.0 parts bone meal and 1.0 part CIAT trace mineral premix is recommended for free choice feeding. In addition it is suggested that salt be supplied ad lib.

b) Zinc sulfate can be substituted for zinc oxide, adding equivalent amounts of zinc in both instances.

Formulated by: Ned S. Raun - CIAT

The main object in forming this Composite was to develop a quality protein population which can serve as source material for further selection in different tropical areas of the world. Also development of such a broad based population will provide better opportunities of selection for capitalizing on modifier genes that affect kernel phenotype and endosperm characteristics.

The Composite has undergone three cycles of mass selection for more protein and tryptophane in the maize endosperm coupled with superior agronomic plant type and disease and insect resistance.

2. COMPOSITE J

This Composite was synthesized by mixing opaque-2 and floury-2 converted materials in two genetic backgrounds namely Puebla gr. 1 and Celaya Composite II. This population was formed with the idea of developing a high quality protein population for areas of intermediate elevation (about 1800 meters) which can be used as source stock for further selection.

This Composite has already undergone two cycles of mass selection for more protein and tryptophane along with other desirable agronomic traits.

3. COMPOSITE I.

This Composite was developed for high elevation areas by pooling together opaque-2 and floury-2 converted materials that had varying number of backcrosses to the recurrent parent. The basic materials included in the formation of this Composite are Mexican gr. 10, Hidalgo-8, Pinto Salvatory, and Puebla gr. 1.

This high quality protein population will serve as raw material for further selection in developing an improved population which has more protein and tryptophane besides having other desirable agronomic characters.

4. CIMMYT OPAQUE-2 COMPOSITE 1

The object in synthesizing this Composite is to develop a broad based opaque-2 population which can be used as source material for further improvement of protein and its quality along with yield and other desirable agronomic characters in different countries.

This Composite is being formed from 56 opaque-2 converted materials that were received from Brazil, Colombia, Venezuela, Nicaragua, Pakistan, Thailand and Philippines. This also includes materials developed in Mexico. A complete list of materials which go into the formation of this composite is given in Table 4.

This Composite is in the first cycle of synthesis and it will be random mated for 3-4 generations to achieve reasonable good mixing.

5. CIMMYT FLOURY-2 COMPOSITE 1

A separate floury-2 Composite is being developed with the same objective as CIMMYT opaque-2 Composite. Twenty two floury-2 conversions from Mexico, Thailand, Philippines and Brazil are being put together to form this Composite. More floury-2 conversions are likely to be added next year that were received relatively late in this season. This is the first cycle of synthesis of this Composite. The materials that have been included in the formation of this population are given in Table 5.

6. THAI OPAQUE-2 COMPOSITE 1

This Composite has been developed by the National Corn and Sorghum Research Centre of Thailand. Nine different opaque-2 converted materials were composited in the year 1969 to develop this Composite. The materials include Ant. 2 D, Cuban flints and some "CM lines" from the Coordinated all Indian maize programme. This Composite was obtained from Thailand and is now undergoing second cycle of mixing.

There is also a great interest in identifying additional mutants in maize which influence protein quantity and quality. The procedure adopted for this purpose is given in Appendix 1. There is evidence that hard kernels can be combined with high lysine content. Colorimetric estimation of tryptophan content is used to determine the quantity of lysine present.

2. Triticale improvement

Several strains of Triticale capable of yielding about 6 tonnes per hectare are now available. The fertility and seed filling are good in some of the Armadillo genotypes. It would be advisable to test the resorcinol content in Triticale lines. Dr. Borlaug is optimistic about the possibility of releasing Triticale strains for commercial cultivation soon.

Table 4

Materials included in the formation of CIMMYT Opaque-2
Composite No. 1

<u>S.No.</u>	<u>Pedigree</u>	<u>Country of origin</u>
1.	Nicarillo	Mexico
2.	Frances Largo	"
3.	Antigua Group 2	"
4.	La Posta	"
5.	Composite grano duro	"
6.	Eto Blanco	"
7.	Eto Amarillo x Granos Amarillos	"
8.	PD(MS) ₆ x granos amarillos	"
9.	Cuba 11 J -- Eto Amarillo - PD (MS) ₆ x granos amarillos	"
10.	Poblacion Cristalina	"
11.	T ₁₁	"
12.	A ₆	"
13.	A ₂₁	"
14.	A ₁₂	"
15.	Composite Jamaica	"
16.	Tuxpeno Selected	"
17.	Tuxpeno Crema 1	"
18.	Mix. I - Col. gr. I x Eto Blanco	"
19.	Tuxpeno - PD(MS) ₆ Sel. Amarillo	"
20.	Granos Amarillo x Cuba 11 J	"
21.	Tuxpeno x Ant. gr. 2 Sel. Blanco	"
22.	Comp. Blanco Caribe	"
23.	Azteca Opaco	Nicaragua
24.	Opaque-2 dent	Pakistan
25.	Western white	Nigeria
26.	Bulk 3 V 102	"
27.	Tuxpeno V 250 C	Mexico
28.	Opaque-2 (selected)	Pakistan
29.	Agroceres 501	Brazil
30.	Esalq opaco	"
31.	Opaque-2 in dent	Brazil
32.	Opaque-2 in flint	"
33.	ICA - H 255	Colombia
34.	ICA - H 208	Colombia
35.	ICA - HH 104	Colombia
36.	Thai Opaque-2 Composite 1	Thailand
37.	Antigua 2 D	"
38.	Veracruz 181 x Ant. Gr.2	"
39.	Caribbean mixed Composite	"
40.	Flint Compuesto Amarillo	"

Table 4 (continued)

<u>S.No.</u>	<u>Pedigree</u>	<u>Country of origin</u>
41.	T-0 ₂ -11	Poey Hybrid -Mexico
42.	T-0 ₂ -38	" " "
43.	Tropical Opaque-2 Composite	Mexico
44.	Compuesto opaco-2	Colombia
45.	Maya Opaco	"
46.	Eto Blanco (O ₂ O ₂)	Philippines
47.	Poblacion Cristalina	Mexico
48.	Tunapuy Opaco-2	Venezuela
49.	Foremaiz Opaco-2	"
50.	Simeto Opaco-2	"
51.	Sicarigua Mejorado Opaco-2	"
52.	Venezuela-I Opaco-2	"
53.	Compuesto opaco-2 No.1	"
54.	Compuesto Opaco-2 No.2	"
55.	Opaque-2 (Yellow)	Ghana
56.	DH-253	Colombia

Table 5

Materials included in the formation of CIMMYT Flourey-2
Composite No. 1

<u>S.No.</u>	<u>Pedigree</u>	<u>Country of origin</u>
1.	Tuxpeno Crema I	Mexico
2.	Eto Blanco	"
3.	Mix.Col. gr. I	"
4.	Mix. I - Col. gr. I x Eto Blanco	"
5.	Tuxpeno-PD (MS) ₆ Sel. Amarillo	"
6.	PD(MS) ₆ - Gr. Amarillos	"
7.	PD(MS) ₆ - Cuba 11 J - Eto Amar.	"
8.	La Posta	"
9.	Compuesto grano duro	"
10.	Nicarillo	"
11.	Antigua gr. 2 Sel. Blanco	"
12.	Frances Largo	"
13.	T ₁₁	"
14.	A ₆	"
15.	A ₂₁	"
16.	Thai Flourey-2 composite	Thailand
17.	T-fl ₂ -40	Poey Hybrid - Mexico
18.	UPCA var. 2	Philippines
19.	Cebu white flint	Philippines
20.	Flourey-2 in flint	Brazil
21.	Flourey-2 in dent	Brazil

3. Potato improvement

Toluca Valley provides an excellent screening area for late blight resistance. India is already taking advantage of this facility. Crosses between Solanum andigena and S. tuberosum have given outstanding hybrids.

4. Wheat breeding

We already have very close collaboration with CIMMYT in wheat improvement work. Some outstanding dwarf durum lines have been developed by Dr. Varughese which have yielded in trials over 8 tonnes per hectare.

5. Organisation of quality research

An outstanding characteristic of the quality laboratory under Dr. E. Villegas is the way in which the work is organized. The breeder and the quality scientist work as members of one team and help each other during peak periods of work. Over 12, 000 samples of wheat were tested for Pelshenke value between October 26th and November 14th by eight workers.

Micro quality tests are being standardized for different purposes. For example, the following tests are used for assessing the Macroni making properties of Triticum durum:

- a) KOH - alkali digestion test.
- b) Determination of Carotenoid content (10 ppm would be very desirable but 6 ppm should be the minimum)

There was great interest in CIMMYT for initiating a joint training programme with I.A.R.I. on the model of the IARI - IRRI Joint Training Programme.

IV. Material obtained

I could collect several hundred seed samples in a wide range of pulse crops, sunflower, Sorghum, maize, groundnut, wheat, cotton and vegetables and these have been distributed to the concerned Project Coordinators and other scientists by the Plant Introduction Division.

Search for High Protein Quality Mutants.

There is interest in locating additional mutants in maize which influence protein level and protein quality. Two known mutants found in dent corn varieties (opaque-2 and floury-2) were found to alter certain essential amino acids in maize endosperm, particularly lysine and tryptophane, which greatly improved the nutritional value of stocks into which the mutants were transferred. They have therefore been the source of considerable interest in an attempt to improve protein quality in most maize growing areas. Certain associated problems with homozygous genotypes have resulted in breeding activities designed to correct these undesirable effects. Opaque-2 particularly, is characterized by slower drying at maturity, greater ear and kernel rots probably as the result of slower drying, and lower test weight. Although these factors will no doubt be largely corrected with time, the possibility of finding other, better, mutants is a factor to be reckoned with and was considered to be worthy of some search and study.

The first attempt at a search for new mutants (which are most likely to be recessive in nature) was initiated at CIMMYT in Mexico in 1968. This was made possible by the development of a rapid colorimetric method of analysis for tryptophane and the opportunity to make single kernel analyses with the seeds thus analyzed saved for planting if desired. Tryptophane and lysine were found to be highly correlated in maize endosperm tissue thus making the simpler tryptophane analysis of value in screening.

The procedure used was as follows :

- 1) Self pollinate 100 plants in a variety or collection.
- 2) Analyze each S_1 family on a sample basis for protein and tryptophane.
- 3) If any family showed higher than average tryptophan, analyses were made on a sample of 10 seeds individually to learn if the family might be segregating for a favorable mutant. This would be indicated if 1 seed in 4 was found to be unusually high in tryptophane.
(The procedure was occasionally carried out so as to spare the embryo and permit growing of any particularly high value seeds).
- 4) If individual seeds found to have high tryptophane values were not maintained for propagation, a sample of any family showing them was planted and 15-20 plants self-pollinated. The resulting S_2 ears were analyzed to test for the presence of a homozygous ear for any high protein quality mutant which might be present. Again if any S_0 plant were

heterozygous for a favourable mutant
1 plant out of 4 should result in a homozygous
ear being high in tryptophane.

The time and labour involved in carrying out tryptophane analyses is at best a limiting factor in looking at the number of samples needed to locate rare mutants. In as much as flint and dent maize types are characterized by highly translucent seeds it may be possible to survey much larger number of plants in the search for rare new mutants of the type desired. If it is true that higher tryptophane and higher lysine types tend to be opaque in nature one can use this characteristic to good effect. The procedure outlined below is based upon some preliminary results which seem to merit further study:

1. Self pollinate 1000 plants in a variety.
(This would permit detection of a mutant with $q = .001$ giving ± 2 segregating plants/1000).
2. Observe each S_1 progeny over a frosted glass with proper illumination below.
3. Any family showing opaque or near opaque seeds would be a potential source of a new protein mutant. Select those seeds showing the greatest degree of opaqueness. A sample of the more normal seeds should be saved from these families also.
4. Analyze a sample of the selected "opaque" seeds and of the normals for each family in which a difference occurs. If the "opaque" seeds result in high levels of tryptophane the remanant (opaque seeds) should be planted for self-pollination to produce S_2 ears. The S_2 ears from these plants would be shelled and the seed examined as before over a frosted glass. Any showing 100% opaque would be homozygous for the mutant responsible for increased amino acid (tryptophane) content.

Should new mutants be found, continued study to determine their value and phenotypic effects should be made. Also, a composite of the various new mutants together with presently known ones would seem worthy of study.

A number of S_1 families from various sources were analyzed by Dr. Villegas during 1969. Some of the sources which gave evidence of the presence of favourable high quality mutants (Table 1) should be more adequately sampled. The promising

families are being regrown to produce S_2 's for further evaluation. Any families resulting from the presence of a favourable mutant should give 1 of 4 homozygous as pointed out above.

An attempt to improve protein quality through the quantitative approach was initiated with selected individual seeds in Puebla Group 1 which is being advanced to Pue Gpo 1 (HT) C_1 syn-2 during the 1969-70 winter planting. A new set of S_1 's will be produced during the temporal planting at Roque in 1970.

In both of the above two populations an evaluation of the C_0 and C_1 (syn-2) should give some indication of possible progress. A continuation of the procedure for one or two more cycles (C_2 - C_3) should be carried out for more critical evaluation of the procedure.

Rome

1971

Report of Dr. M.S. Swaminathan, Director,
Indian Agricultural Research Institute,
New Delhi, on his deputation to Rome for
attending the 1st Meeting of the Inter-
national Technical Advisory Committee on
Agricultural Research constituted by
FAO - World Bank - UNDP

Recently a Consultative Group has been formed for sponsoring and stimulating International Agricultural Research. The objectives and other details relating to the Consultative Group are as follows:

OBJECTIVES:

The main objectives of the Consultative Group (assisted as necessary by its Technical Advisory Committee (TAC)) are:

- i. on the basis of a review of existing national, regional and international research activities, to examine the needs of developing countries for special effort in agricultural research at the international and regional levels in critical subject sectors unlikely otherwise to be adequately covered by existing research facilities, and to consider how these needs could be met;
- ii. to attempt to ensure maximum complementarity of international and regional efforts with national efforts in financing and undertaking agricultural research in the future and to encourage full exchange of information among national, regional and international agricultural research centres;
- iii. to review the financial and other requirements of those international and regional research activities which the Group considers of high priority, and to consider the provision of finance for those activities, taking into account the need to ensure continuity of research over a substantial period;
- iv. to undertake a continuing review of priorities and research networks related to the needs of developing countries, to enable the Group to adjust its support policies to changing needs, and to achieve economy of effort; and

Contd....p/2

- v. to suggest feasibility studies of specific proposals to reach mutual agreement on how these studies should be undertaken and financed, and to exchange information on the results.

In all of the deliberations of the Consultative Group and the Technical Advisory Committee, account will be taken not only of technique but also of ecological, economic and social factors.

COMPOSITION:

The co-sponsors of the Group are the Food and Agriculture Organisation of the United Nations (FAO), International Bank for Reconstruction and Development (IBRD), and the United Nations Development Programme (UNDP). As of June 1, 1971, its membership, in addition to the co-sponsors, consists of the following countries, regional development banks, private foundations and other organisations interested in supporting international agricultural research related to the problems of the developing countries:

<u>Governments</u>	<u>International Organisations</u>	<u>Others</u>
Canada	African Development Bank	Ford Foundation
Denmark	Inter-American Development Bank	IDRC
France		Kellogg Foundation
Federal Republic of Germany		Rockefeller Foundation
Netherlands		
Norway*		
Sweden		
United Kingdom		
United States		

* Subject to final approval by appropriate Norwegian authorities.

The following are participating in the Group as observers:

<u>Governments</u>	<u>International Organisations</u>
Australia	Asian Development Bank
Belgium	Development Assistance Committee of OECD
Finland	European Development Fund

Contd....p/3

GovernmentsInternational Organisations

Italy
 Japan
 New Zealand
 Switzerland

Some of the observers have indicated they may join as members.

Arrangements will be made through FAO for the designation, for a period of two years, of not more than five governments, each representing a major region of the developing world, to participate as members of the Group. Other interested parties may be invited to join the Group or to participate as observers, as decided by the members.

Membership in the Group involves no commitment to provide funds.

The Chairman and Secretary of the Group will be provided by the IBRD and its base will be at IBRD headquarters in Washington, but the venue of its meetings will be decided from time to time by its members.

The Consultative Group at its meeting held in Washington on May 19 : 1971, decided to constitute a Technical Advisory Committee (TAC) constituting of the following Members:

1. Sir John Crawford (Economist), Chancellor,
 Australian National University, Canberra.
 To serve as Chairman. - Australia
2. Ing. Manuel Elgueta (Agronomist), Ex-Director,
 Chilean Agricultural Research Institute; now
 working with IICA as Director of proposed
 Turrialba Research Corporation. - Chile
3. Prof. Dr. Hassan Ali El-Tobgy (Geneticist),
 Under-Secretary, Agriculture and Chairman,
 Research Committee. - U.A.R.

Contd...p/4.

4. Prof. H. Fukuda (Irrigation Specialist), Vice President, International Commission for Irrigation and Drainage, Tokyo University. -- Japan.
5. Dr. G. Harrar (Plant Pathologist), President, Rockefeller Foundation. -- U.S.A.
6. Dr. D. Hopper (Economist), President, International Development Research Center. -- Canada
7. Dr. Luis Marcano (Agronomist), President Shell Foundation. -- Venezuela
8. Dr. I.E. Muriithi (Animal Health), Director, Veterinary Services. -- Kenya
9. Dr. J. Pagot (Animal Production), Director General, Institut d'Elevage et de Medecine Veterinaire des Pays Tropicaux. -- France
10. Dr. V. Pereira (Physicist), Director, East Malling Research Station, Kent (previously Director, Central African Research Organisation) -- U.K.
11. Dr. L. Sauger (Agronomist), Directeur, Centre de Recherche Agronomique due Bambey. -- Senegal
12. Dr. M.S. Swaminathan (Geneticist), Director, Indian Agricultural Research Institute, New Delhi. -- India

The following are the functions of the TAC:

TAC will, acting either upon reference from the Consultative Group or on its own initiative:

- i. advise the Consultative Group on the main gaps and priorities in agricultural research related to the problems of the developing countries, both in the technical and socio-economic fields, based on a continuing review of existing national, regional and international research activities;

Contd....p/5.

- ii. recommend to the Consultative Group feasibility studies designed to explore in depth how best to organise and conduct agricultural research on priority problems, particularly those calling for international or regional effort;
- iii. examine the results of these or other feasibility studies and present its views and recommendations for action for the guidance of the Consultative Group;
- iv. advise the Consultative Group on the effectiveness of specific existing international research programmes; and
- v. in other ways encourage the creation of an international network of research institutions and the effective interchange of information among them.

These terms of reference may be amended from time to time by the Consultative Group.

FAO has agreed to provide the Secretariat for TAC and funds for the expenses of the TAC will be borne by the World Bank, UNDP and FAO.

The first meeting of the TAC was held in Rome from June 29 to July 2 : 1971. The following attended:

Members

Sir John Crawford	-	Australia (Chairman)
Ing. Manuel Elgueta	-	Chile
Prof. Dr. Hassan Ali EL-Tobgy		UAR.
Prof. H. Fukua	-	Japan
Dr. W.D. Hopper	-	Canada
Dr. Luis Marcano	-	Venezuela
Dr. I.E. Muriithi	-	Kenya
Dr. J. Pagot	-	France
Dr. H.C. Pereira	-	United Kingdom
Dr. L. Sauger	-	Senegal
Dr. M.S. Swaminathan	-	India

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Observers

- Mr. R.D. Demuth, Director, Development Services
Department, IBRD
- Mr. L.J.C. Evans, Director, Agriculture Projects
Department, IBRD
- Mr. A. Kruithof, Development Services Department, IBRD
- Mr. J. Pino, Director, Agricultural Sciences, Rockefeller
Foundation
- Dr. F.F. Hill, Ford Foundation
- Dr. M. Gucovsky, Senior Technical Adviser, Bureau for
Programme Coordination, United Nations Development
Programme
- Dr. Omer J. Kelley, Director, Office of Agriculture and
Fisheries, Bureau for Technical Assistance, US AID
- Prof. W.A.J. Flaig, Federal Republic of Germany

A copy of the Agenda is given in Appendix - I.

I was elected Deputy Chairman of the Technical Advisory
Committee.

The following are some of the principal points of interest
to India:

1) Establishment of an International Upland
Crops Research Institute:

The background paper prepared by Dr. Gray of the
Rockefeller Foundation was discussed at length and it was decided
to nominate a Technical Group consisting of Dr. R.W. Cummings,
Dr. L. Sauger and Dr. H. Doggett to visit India and West Africa and
submit detailed recommendations concerning the location best suited
for establishing this International Research Institute. Most of the
Members considered India as the suitable country for locating this
Institute and it was felt that while the Main Centre might be in
India, an Associated Centre could be established in Africa.

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On my suggestion, it was decided that the Institute should be structured on a systems approach rather than on a crop approach.

2) Research on Pulses:

A paper prepared by Dr. Roberts of the Rockefeller Foundation was discussed and the Committee agreed with my view that instead of distributing such research in various existing International Research Centres, it would be useful to establish a very well-supported Multi-disciplinary Research Centre which can work intensively on opening up new vistas in the yielding ability of these crops. It was decided that the matter should be discussed by Dr. Elgueta, Dr. Oram and myself with Dr. Roberts and a note presented at the next meeting of TAC.

3) Support to existing International Institutes:

The requests for additional funds for the International Rice Research Institute, Philippines, the International Maize and Wheat Research Centre, Mexico and the International Institutes for Tropical Agriculture in Colombia and Nigeria were considered. It was decided that different Members of TAC should discuss the matter further with the respective Boards of Management. I was asked to review the requirements of the Institute in Nigeria with the Board Members on September 15-16 : 1971.

4) Water Management:

It was decided to organise a travelling seminar in Asian Countries to understand what kind of research in the field of Water Management requires urgent emphasis.

5) Funds available for International Research:

TAC was informed that about 15 million dollars per year may be available for supporting International Research Projects in Agriculture. In addition, the US Government has undertaken to meet 25 per cent of the annual budget of new International Research Institutes.

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6) Dates for the Next Meeting:

It was decided to hold the next meeting of the TAC from October 19 - 23 : 1971, in Rome, so that the recommendations of the TAC could be submitted well in time for being considered by the Consultative Group which is scheduled to meet in December, 1971.

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June : 71.

FAO

PROVISIONAL AGENDA FOR FIRST MEETING OF TECHNICAL
ADVISORY COMMITTEE*

1. Adoption of Agenda
2. Opening Statement by Director-General, FAO
3. Report on current status of Consultative Group on International Agricultural Research (to be presented by IBRD)
4. Discussion of the role and procedures envisaged for TAC and related technical working groups (Introduction by Chairman)
5.
 - a) Programmes and prospective requirements of CIAT, CIMMYT, IITA and IRRI (Oral presentation by representatives of Ford and Rockefeller Foundations)
 - b) Reports on other existing international agricultural research programmes (oral presentation by selected speakers)
6. Status of work related to specific indentified gaps in agricultural research in developing countries:
 - a) Upland or rainfed crops, including millet and sorghum
 - b) Food legumes
 - c) Animal health and livestock production in tropical Africa
 - d) Water use and management
 - e) Rice development in West Africa
 - f) Potato improvement in Latin America
 - g) Vegetable production in Asia and the Far East
(Oral presentation by selected speakers)

* Supporting documents on items 5-8 will be tabled at the meeting.

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7. Discussion of problems of agricultural research in developing countries not adequately covered under items 5 and 6 e.g.
 - improving systems of agriculture, including livestock, in semi-arid and arid areas (Near East and Africa)
 - grassland and range management (International Grazing lands programme)
 - developing livestock production in S.E.Asia
 - rodent control
 - multiple cropping
 - socio-economic or environmental implications of new agricultural technology.....etc.,...etc.

(Oral presentation by TAC Secretariat)
8. Development of an appropriate agricultural research information system for developing countries. Proposal to be presented by FAO
9. Recommendations for further action on items 5-8
10. Any further business
11. Date of next meeting.

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Visit to Washington, D.C. from
July 25, to August 3, 1973

Deputation Report of

Dr. M.S. Swaminathan, FRS

Deputy Chairman, Technical Advisory Committee
to the Consultative Group on International
Agricultural Research.

on

- (a) Meetings of the Technical Advisory Committee and the Consultative Group for International Agricultural Research.
- (b) Executive Committee Meetings of
 - (i) The International Crops Research Institute for the Semi-arid Tropics, Hyderabad.
 - (ii) The International Maize & Wheat Research Centre, Mexico.
- (c) Community participation in agricultural development.

I attended the meetings of the Technical Advisory Committee to the Consultative Group on International Agricultural Research and associated meetings at the headquarters of the International Bank for Reconstruction and Development, Washington, from July 25th to August 3rd, 1973. The agenda for the meetings is given in Appendix 1. The names of the participants at the meetings are given in Appendix II. During my stay in Washington, I also attended the meetings of the Executive Committees of the International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, and the International Maize and Wheat Research Centre, Mexico. I had discussions with Mr. McNamara, President, World Bank Group, and also attended various meetings arranged at the initiative of the World Bank, IDRC, ODA, etc. I attended a reception held by the Indian Ambassador in honour of the Union Minister of Finance, Shri Y.B. Chavan. The main points of

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interest at the various meetings are given below:-

PART I

Meetings of the Technical Advisory Committee (TAC),
Consultative Group on International Agricultural
Research and Socio-economic research Seminar.

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(i) Priorities for international support to agricultural research in developing countries.

This topic had been discussed in an earlier meeting of the Technical Advisory Committee and TAC finalised its priority paper at the present meeting. The priority paper envisages an approximate investment of 80 million US dollars by the Consultative Group on International Agricultural Research by 1980. Since this paper is a very important one from the view-point of our formulating proposals for international support, I append an unabridged text of this paper (Appendix III).

(ii) Support to international agricultural research centres.

The following research centres exist at present which are supported by the Consultative Group:-

<u>Name of Centre</u>	<u>Year of establishment</u>	<u>Main Research Thrust</u>
1. IRRI (International Rice Research Institute) Los Banos, Philippines.	1960	Rice and farming systems for rice.
2. CIMMYT (International Maize and Wheat Improvement Centre) Mexico.	1966	Maize, Wheat, barley, rye, triticale
3. IITA (International Institute for Tropical Agriculture) Ibadan, Nigeria.	1967	Farming systems for lowland humid tropics including work on mgizo, rice, tubers, food legumes.
4. CIAT (International Centre for Tropical Agriculture) Cali, Colombia.	1968	Farming systems for the tropics with emphasis on beef, swine, cassava, maize, rice and beans.
5. IPC (International Potato Center) Peru	1972	Potatoes.
6. ICRISAT (International Crop Research Institute for the Semi-Arid Tropics) India.	1972	Sorghum-millet, food legumes and farming systems for semi-arid tropics.

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The Technical Advisory Committee after a detailed consideration of the programmes and budgets of these institutes made the following recommendations for financial allotment during 1974.

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Estimates of Center Requirements, 1974
(\$ million)

	<u>Core</u>	<u>Capital</u> b/	<u>Total</u>
CIAT	4.40	1.50	5.90
CIMMYT	5.13	.41	5.54
CIP	1.94	.31	2.25
ICRISAT	2.60	3.00	5.60
IITA	5.92	.50	6.42
IRRI	3.25	1.49	4.74
Gene Network c/	.52	.09	.61
WARDA c/	.53	.09	.62
ILRAD			.95 d/
ILCA			.50 d/
	<u>24.29</u>	<u>7.39</u>	<u>33.13</u>

a/ Amounts rounded to the nearest \$ 10,000. The figures are based on the budget presentations of the international agricultural research centers, except as otherwise indicated.

b/ CIAT's capital budget has not yet been formally approved by its Board of Trustees.

c/ As presented to TAC.

d/ Secretariat rough estimate.

The manner of relating programmes and budgets by the international centers is worthy of emulation and I am getting the proforma used by them examined in the I.C.A.R. for being adopted with suitable modifications.

(iii) Projected requirements of international research centres and new projects under examination by 1980.

After detailed discussion, it was decided that the approximate requirements of the existing centres as well as of the new projects will be of the order mentioned in appendix IV. Among the projects approved

- 4 -

earlier by TAC, those which are likely to become operative soon are the International Livestock Research Centre and the International Laboratory for Research on Animal Diseases both to be located in Africa.

(iv) Report of the research review mission to the Near East and North Africa.

This review mission constituted by TAC under the leadership of Dr. D. Skilbeck of U.K. has recommended the establishment of an International Research Centre for Mediterranean Agriculture with headquarters at Beirut. This research centre will cater to the needs of Pakistan, Afghanistan, Iran, Jordan, Syria, Iraq, Kuwait, Saudi Arabia, Yemen, Oman, Somalia, Sudan, Egypt, Lebanon, Cyprus, Libya, Tunisia, Algeria, and Morocco. The major aims of this research centre will be as follows:-

- (i) To improve the utilisation of land and water resources by research, to improve basic data and to identify and remove the major constraints to intensification of land use.
- (ii) To increase or stabilise yield per hectare of the major food commodities, especially wheat and barley, grain legumes, and annual oilseeds, by the development of improved varieties and related packages of inputs and cultural practices, including research into the role and value of fallow.
- (iii) To develop more productive farming systems with special emphasis on (a) crop-livestock integration and the introduction of fodders into arable rotations; (b) encouragement of inter-zonal complementarities; (c) multiple cropping systems in irrigated areas; (d) the creation of employment opportunities.

Dr. H. Haque, Director-General of the Pakistan Research Council, who was present at the meeting as one of the representatives of the developing countries on the Consultative Group made a strong plea that

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the new Institute should be located in Pakistan and not in Lebanon. In view of the controversy about the location and also in order to sharpen the research priorities of this Centre, it was decided that a Sub-Committee of TAC comprising of Dr. David Hopper, Dr. D. Bommer and myself should meet some time in November in Rome and make our recommendation to the next meeting of TAC scheduled to be held early in February, 1974 in Rome.

(v) Support to West African Rice Development Association (WARDA).

Fourteen nations of West Africa comprising Dahomey, Gambia, Ghana, Guinea, Ivory Coast, Liberia, Mauritania, Mali, Niger, Nigeria, Senegal, Sierra Leone, Togo and Upper Volta decided in 1969 to set up a West Africa Rice Development Association (WARDA) in order to improve rice production in West Africa speedily. The headquarters of WARDA is located at Monrovia. WARDA submitted to TAC a research proposal costing over a million dollars for achieving a rapid improvement of rice research in West Africa. In its concept, WARDA is more or less based upon the model of our All India Coordinated Research Project on Rice. In fact, the Executive Secretary of WARDA, Dr. Diouf paid great compliments to the All India Coordinated Research Project on Rice and thanked the ICAR for sending research material to WARDA. I strongly supported the WARDA proposal and TAC recommended the WARDA project for support by the Consultative Group on the understanding that WARDA will have a scientific steering Committee which would help to provide the requisite technical guidance to the project.

(vi) Aquaculture.

The TAC Panel on Aquaculture could not finalise its full report. However, a summary was presented by Prof. Bardach and the group recommended that the most effective way to reinforce present research efforts was to concentrate on a few specific problems of immediate

economic value. These are carps, catfish, tilapia, milkfish, mullets and shrimps. The Group concluded that the highest priority for the most fruitful new research effort lies in the field of reproductive physiology and selective breeding. The Group also noted that a strong priority exists in the realm of food and feeding, an area of aquaculture whose implementation is relatively less amenable to centralisation. High priority research is also required in disease control and the broad spectrum of water quality problems related to the cultured animal and its aquatic environment. Dr. Jhingran, Director, Central Inland Fisheries Research Institute, was a member of the Panel. The full report of the Panel will be discussed at the next meeting of TAC in February, 1974 and I expect substantial assistance to our national programme on coastal and inland aquaculture.

(vii) UNCTAD resolution No. 50 on competitiveness of natural Products, synthetics and substitutes.

TAC has given the highest priority to food crops. However, it was decided that TAC would offer comments on specific projects on fibres and any other crop that may be placed before it by any of the sponsoring organisations. Meanwhile, FAO was asked to take up a detailed study of the research needs of agricultural raw materials. There was sympathy for the proposed International Jute Research Centre to be established in Bangladesh.

(viii) Conservation of world genetic resources.

This project was approved and it was decided to get it implemented from 1974. Although no centre has been proposed in India immediately, the President of IDRC, Dr. Hopper, indicated that IDRC would like to support a research centre in India as soon as the proposed National Bureau of Plant Introduction and Exploration is established under the Fifth Plan.

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(ix) International Soybean Resource Base (INTSOY)

The proposal made by the University of Illinois for helping developing countries to improve soybean production was generally welcomed. Further details were, however, sought concerning the nature of policy control over the project. I stressed the need for looking at soybean both as a protein and an oilseed crop, since unlike in the developed countries, there is need in poor nations to step up the per capita consumption of oils.

(x) Reaction of CG to TAC recommendations

The Consultative Group generally endorsed all the recommendations of TAC and pledges were made by different members of the Consultative Group for over 30 million dollars for support for international agricultural research during 1974. The Consultative Group will again meet in November, 1973, when firm commitments will be made by the different countries and international organisations.

PART II.

Meetings of Executive Committees of the Boards of Trustees of the International Crops Research Centre for the Semi - arid Tropics (ICRISAT) at Hyderabad and the International Maize and Wheat Research Centre (CIMMYT) Mexico.

I attended the meetings of the Executive Committee of ICRISAT on July 29 and August 1, 1973 and of CIMMYT on August 2, 1973. Since there were other regular programmes during these days, the Committee meetings were held in the evenings and during day time on Sunday, July 29. The important points discussed were the following:

(a) ICRISAT

i) Role of groundnut research:

It was decided that this should be discussed at the Programme Committee meeting to be held later in August, 73, at Hyderabad.

ii) Reduction in the cost of buildings to offset the effects of inflation and to reduce ostentation.

The plans submitted by the Architects were scrutinised in great detail and it was decided to effect the following economics:

1. Bring in the HT power line, overhead rather than buried, from the BHEL/ICRISAT boundary line westward to a point south of the utility services building. This line can be extended aerial to the "well filed".
2. Simplify and reduce the cost of the gatehouse and entrance gates from the estimated cost of Rs. 200,000.
3. Eliminate the evaporative cooling systems from the canteen and laundry.
4. Simplify and reduce the size and expansiveness of the guest house/club. Eliminate the Director's reception area. Reduce the office spaces from three to one. Reduce the number of shops and delete the commissary. Reduce the number of suites and reconsider the number of single rooms.

5. Simplify the design of the Director's house and reduce the estimated cost of Rs. 560,000.
6. Standardize the international staff housing in terms of basic requirements (ground floor) with the major difference between houses being only in the number of bedrooms.
7. Reconsider the widths of roads and consider the alternative of having concrete roads in lieu of asphalt roads.
8. Reduce the extensive use of pergolas which are presently estimated at Rs. 550,000.
9. Find alternative solution for courtyard pavings and compound walls in the housing area presently estimated at Rs. 1,740,000. Are there alternate and less expensive solutions to the boundary walls in housing and other areas? The architects have suggested concrete blocks with exposed (granite) aggregate finish. Could solid granite be used? Could plantings be used?
10. Consider the use of sewage lagoons instead of a sewage treatment plant presently budgeted at Rs. 250,000.
11. Reduce the number of fire and lawn hydrants presently budgeted at Rs. 1,200,000.
12. The Doshi-Stein report indicates a laboratory effluent disposal unit costing Rs. 350,000. What does this consist of? Is this required?
13. Reduce the number of exterior lights (and exterior illumination level) presently estimated at Rs. 450,000.
14. Pools and fountains have been estimated at Rs. 160,000. Do these pools and fountains serve useful purposes? What will be the maintenance costs of these pools and fountains? They may be deleted unless they are related to the airconditioning water pool.

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15. The architects have noted the use of demountable wooden partitions in the administration building. Perhaps there are alternative solutions which are less expensive.
16. With reference to exterior cladding, would solid granite blocks be more or less expensive than concrete blocks using granite as an exposed aggregate ?
17. Fiberglass and aluminum fly screens should be considered rather than bronze fly screening.
18. Is it absolutely necessary to have a pressurized water main for fire fighting ? Will the gravity tank on the EAST boundary (plus a portable fire pump) provide sufficient pressure for this purpose at a reduced cost ?
19. Should the warehouse, stores and guest/club be attached to the central air conditioning system ? Would it be better to have package units for these buildings or even window units because of their remoteness from the central plant ?
20. Eliminate mechanical ventilation and provide natural ventilation in chemical stores.
21. Eliminate plaster and paint in air handling rooms, work areas, warehouses and workshops.
22. Is it desirable to have formica lined doors in the laboratories ? What are the alternatives ?
23. Is it desirable to have polished shahabad/terrazo floors in the laboratories ? Would vinyl asbestos flooring be better and less expensive ?
24. Is curbing required along all roads and streets ?

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25. Are sidewalks required along all roads and streets ?
26. Should electrical earthing cost Rs. 60,000?
27. Does the Director's residence require 20 tons of refrigeration ?
The air conditioning load in other international staff housing has been estimated at seven tons per house.
28. Utility (laundry rooms) would be satisfactory with monolithic concrete floors.

The Director was asked to discuss the above points with the architects and bring down the cost of the building as much as possible.

(b) CIMMYT

i) Training programme:

In order to maximise the benefits of the outstanding training programme conducted by Dr. Norman E. Borlaug in wheat, I suggested a "Roving Training Programme" which could help to get for the world the maximum benefits from Dr. Borlaug's outstanding gifts in instilling into young workers the will to win. This was agreed to and we will draw up a suitable programme of training in India, in which we will have the benefit of Dr. Borlaug's participation.

ii) Appropriate Agricultural Technology for small farmers:

We debated at great length the appropriateness of current research to the needs of farmers with small holdings and the question whether additional research is needed to develop intermediate or appropriate agricultural technology for poor farmers. The main conclusions of this discussion are given below with regard to the various facts of this problem.

No.1. Some farmers in developing countries are handicapped by multiple disadvantages.

CIMMYT accepts the generalization that some farmers in developing countries enjoy multiple benefits while others are handicapped by multiple disadvantages.

. . . . contd.

These advantages and disadvantages can be generalised:

More advantaged farmers:

Larger land holdings.

Better soil.

Better rainfall or access to irrigation.

Better access to credit.

Better access to fertilizer and other cash inputs.

Better education of farmers.

Better management of skills.

Such farmers generally accept larger cost of inputs and larger risks.

Less advantaged farmers:

Smaller land holdings.

Less desirable soil.

Poorer rainfall or poorer access to irrigation.

Poorer access to credit facilities.

Poorer education of farmers.

Poorer management skills.

Such farmers generally seek lower cost of inputs and lower risks.

Like all generalizations, this one has conspicuous exceptions.

In the Indian Punjab, there are small holders (under 5 hectares or even under 3 hectares) who share all the characteristics of the advantaged group except size of holdings.

In North Africa and the Near East, there are large land holders (over 100 hectares) in rainfed areas who share all the characteristics of the disadvantaged group, except for the size of holdings.

. contd.

Despite the exceptions, the above multiple advantages or multiple disadvantages tend to be associated with each other.

Therefore, the question which USAID has put to CIMMYT might be restated in the following manner, to show more clearly the multiple factors involved.

In what ways is CIMMYT developing technology to meet the needs of the less advantaged group of farmers who often share the following characteristics:

Smaller land holdings.

Poorer soils.

Poorer rainfall in quantity or dependability.

Poorer access to credit.

Poorer access to fertilizer and other cash inputs.

Poorer education of farmer.

Poorer management skills.

The rephrased question brings out that several aspects of the above disadvantages cannot be directly attacked by new technology. New technology can, however, ameliorate some of the consequences of these disadvantages.

The balance of this paper is devoted to the ways in which new technology can be useful to the disadvantaged farmer, i.e. that farmer who is critically concerned about reducing risk as well as increasing income.

No. 2: Available moisture in the root zone establishes an absolute ceiling on yield of a grain crop.

Water is one of the absolute requirements of plant growth. The level of rainfall or irrigation which a farmer receives establishes a ceiling on what yields he can obtain with maize or wheat. Excess rainfall and lack of drainage also constitute an absolute limitation on yield.

. . . . contd.

if a farmer is planting his crops in an area of typically low rainfall, or in a season of untypically low rainfall, or of untypical flooding, this sets a limit on his crop.

For example, in North Africa (Algeria, Tunisia) when wheat is grown under limited moisture, the following relationship now exists between moisture and yield (if other factors are not limiting):

- (a) If moisture is under 300 mm in the growing season, only one wheat crop every 2 years can be grown.
- (b) If moisture is 300 mm, grain yield can be 1,000 kilograms per hectare.
- (c) If moisture is 400 mm, grain yield can be 3,000 kilograms per hectare.
- (d) If moisture is 500 mm, grain yield can be 3,500 kilograms per hectare.

Similar limits upon yield imposed by moisture can be worked out for maize.

While there are unquestionable absolute limits to yield, CIMMYT believes that more research can increase the agronomic efficiency of plants, thereby increasing the yield potential attainable by the farmer. Moreover, within the absolute limits, stability of yield can also be increased and risk can thus be reduced. Nonetheless, it must be recognized that, at any given time, available moisture imposes a ceiling on what the farmer can achieve.

Research on stability of yield and on drought tolerance is discussed more fully later.

No. 3: Available fertility in the root zone establishes an absolute ceiling on the yield of a grain crop. If a farmer is unable or unwilling to provide the nutrients, he must accept limits on yield.

A crop of maize, or wheat, or rice, now contains approximately the following amounts of nitrogen at harvest (adding grain, stover, and roots together):

Table

Nitrogen found in grain-stover- roots of
Maize-Wheat-Rice at different yield levels 1/

Yield of grain (tons/hectare)	Maize Total N found in grain, stover, and roots kg/ha	Wheat Total N found in grain, stover, and roots kg/ha	Rice Total N found in grain, stover, and roots kg/ha
0.5		30	
1.0	22	65	22
2.0	41	108	40
3.0	62	158	59
4.0	85	218	80
5.0	112	285	102
6.0	140	-	125
7.0	169	-	150
8.0	200	-	175
9.0	229	-	201
10.0	259	-	268

1/ Quoted from Soil Nitrogen Technical Bulletin No. 8, North Carolina State University, (USAID Contract la-646), p.13

As far as CIMMYT knows, there is no present way a farmer can grow a ton of certain cereal grain unless the chemicals found in the crop at harvest are available in the soil during the growing season. Cereals do not have the capacity to fix nitrogen from the air, as many legumes do.

..... contd.

Moreover, the nutrients of a cereal crop must be within the root zone, and in a chemical form which is "available" -- that is, can be absorbed by the roots. That requires good management for the higher yields.

The so-called "high yielding varieties" are more responsive to high fertility than the traditional varieties. But they both require in the soil, at the minimum, the amount of nutrients which are later found in the grain, stover, and roots combined.

As is the situation with available moisture, CIMMYT believes that more research can develop new technology which will be more efficient agronomically in the utilization of available nutrients. However, at any given time, availability of nutrients does impose a ceiling on what the farmer can obtain. CIMMYT knows of no way to grow a high yield crop with a low level of fertility.

No. 4: CIMMYT believes that varieties which demonstrate the highest capacity to convert moisture to grain will show a competitive advantage both under irrigation and under moisture stress.

CIMMYT scientists conduct initial crossing and selection for experimental maize and wheats under irrigation. Such a procedure circumvents loss of an entire cycle of selection when drought is severe, and permits selection of those genotypes which have the greatest genetic potential to utilize high levels of moisture and plant nutrients. Next, CIMMYT tests and reselects under widely different conditions, including irrigated and rainfed areas in over 60 countries. Those plants which show the widest adaptation -- will in CIMMYT's judgment have competitive advantage under both irrigated and rainfed conditions.

CIMMYT has no evidence which shows that crossing and initial selection under irrigation with subsequent evaluation and selection under a wide range of conditions results in a loss of genetic potential for any level of production.

That is a basic premise in CIMMYT breeding.

That was the strategy by which the short statured "Mexican wheats" were originally developed.

CIMMYT believes this same principle will prove correct with "widely adapted" maize, but the CIMMYT testing of maize populations for wide adaptation does not yet provide data for independent verification.

No. 5: Plants which are short-statured, with fewer leaves, and can be grown at higher density, tend to be associated with (a) higher proportion of dry matter devoted to grain and (b) higher yields. This competitive advantage should show under both high inputs and low inputs.

Semi-dwarf wheat varieties released by the Mexican Government beginning in 1962 have shown these characteristics when grown under both irrigated and rainfed conditions in Asia, Africa, and Latin America.

The same applies to the semi-dwarf rice varieties of IRRI.

CIMMYT is counting on the same competitive advantage for semi-dwarf tropical maize still under development.

CIMMYT believes that the short plant with less lodging (falling over) and higher yield potential can be of benefit both to farmers using high inputs to gain high yields, and to those farmers seeking lower input costs and lower risks.

No. 6: Short-statured varieties which show the highest response to nitrogen at high application levels, also show competitive advantage at lower levels of nitrogen.

CIMMYT has no data to support the opinion, sometimes expressed in the press by critics of the technological revolution in agriculture, that high yielding varieties require high input costs in order to show competitive advantage.

Short-statured wheat varieties, which have shown "wide adaptation" in Asia, Africa, and Latin America, have also shown a competitive advantage at lower levels of fertility, but the advantage is slight at lower levels of fertility. The advantage rapidly widens as the level of fertility increases.

CIMMYT expects the same competitive advantage to be true with the new, short-statured tropical maize now under development.

No. 7: Has CIMMYT released varieties of maize and wheat which are of special benefit to the farmer who wants lower input costs and lower risks?

CIMMYT does not release varieties. It has never done so. It only distributes its own nurseries of experimental materials, plus varieties released by collaborating countries which can be rescreened in developing countries. By these means, countries can choose materials best suited to their conditions. The best materials may be multiplied and released as local varieties, or may be reselected and subsequently released as local varieties, or they may be used as parent materials for local breeding.

CIMMYT uses this basic strategy for both maize and wheat.

It is indirect contrast to IRRI, which releases varieties.

The question may be restated: Has CIMMYT distributed experimental nursery materials which will provide new technology of value to farmers who want lower input costs and lower risks? The CIMMYT answer is yes, we believe we have.

After tests on experiment stations in Mexico, and after world-wide retesting and reselection of these materials, CIMMYT and the collaborating national programs have identified widely-adapted material which will make efficient use of moisture under both irrigated and rainfed conditions. These also make efficient use of nitrogen under both high applications and low applications.

"Wide adaptation" combines within its selection criteria elements for day length insensitivity, drought tolerance, heat tolerance, cold hardiness, resistance to lodging, and a variety of other forms of stability.

"Wide adaptation" is generally associated with yield stability, and thus helps to reduce risk for all classes of farmers. It is most important to those farmers in areas of undependable rainfall.

Development of wide adaptation through a breeding program and world-wide testing should do much to achieve yield stability, and thus reduce risk. But CIMMYT has found no quick way to achieve wide adaptati

No. 8: Has CIMMYT developed agronomic practices which are of special benefit to farmers who want lower input costs and lower risks?

CIMMYT's agronomic testing in Mexico does not attempt to develop recommended practices for maize and wheat producers in countries outside of Mexico, particularly for countries of Asia, Africa, and Latin America which differ from Mexico in day length, temperature pattern, rainfall pattern, soil type, and cropping rotation.

While CIMMYT's agronomic testing in Mexico can establish the general principles suitable for maize and wheat production under conditions in Mexico, these agronomic trials must then be repeated in other countries in order to establish local values on:

Methods of seed bed preparation.

Date and rate of seeding.

Date, rate and kind of fertilization.

Most effective and economic methods of weed control.

The division of labor between CIMMYT's agronomic research in Mexico, and the agronomic research in the collaborating countries, places special importance on the training of research agronomists from Asia, Africa, and Latin America, in CIMMYT's production training courses in Mexico.

Questions of planting date, planting depth, plant population, fertility level, etc. are all local agronomic practices which affect risk, and thus are of special interest to farmers who want lower risks.

CIMMYT is teaching production trainees in Mexico how to conduct agronomy trials for use when they return to their home country.

. . . . contd.

From the types of agronomic trials taught at CIMMYT, the trained agronomist can formulate packages of practices which will, (a) maximize profits, and/or (b) reduce risks. Varieties selected for wide adaptation can serve both purposes, but the farmer must vary his agronomic practices, according to his objectives. The cost of inputs will also vary according to the farmer's objectives.

CIMMYT believes that in the short run, the dryland farmer can be helped more by agronomic research, than by breeding research.

For example, if a rainfed farmer will apply half his proposed nitrogen fertilizer rate at planting time and withhold the other half until he is assured of adequate rain, he reduces his risk in two ways. First, the half applied at planting will help develop the root system rapidly in many situations, and thus provide a safeguard against early drought. The other half will be invested only after the rains come, and thus his risk is reduced.

No. 9: Drought: What has CIMMYT done to develop maize and wheat lines of special benefit to farmers in areas with lower rainfall or undependable rainfall?

CIMMYT believes there is no "total drought resistance" in plants and CIMMYT is not making any studies on this subject.

All plants will desiccate and die when deprived of the minimum level of moisture required for plant maintenance.

But some plants escape drought; some plants tolerate short periods of drought with less damage to yields than others; and certain plants use water more efficiently. In order to search for these characteristics, CIMMYT has undertaken studies described below.

(a) Drought escape, by length of maturity.

It is a recognized fact in maize and wheat research that some plants escape a drought in late season by having a maturity period that is two weeks to four weeks shorter than other varieties. In other words, the grain filling period is finished before the drought.

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It is recognized also that varieties with longer maturities will sometimes escape a drought that would occur at flowering time in early maturing types, and thus cause a poorer seed set.

CIMMYT is working on a wide variety of maturities for both maize and wheat, in the expectation that grower countries can choose those lengths of growing period which best fit their rainfall pattern.

This type of research can benefit farmers with higher risk in low rainfall areas.

(b) Drought tolerance derived from root structure.

The root structures of both maize and wheat vary widely between varieties, in both outreach of roots and depth of roots. By penetrating a wider and/or deeper soil profile, the root structure can draw upon a wider supply of moisture and thus enable the plant to survive a drought better.

The crown root of winter wheat is superior in drought tolerance to the root structure of the spring wheats, because the winter wheat crown root sets deeper in the soil, the secondary and tertiary roots reach to a greater depth, and develop faster after planting, to provide early drought protection.

CIMMYT has been collaborating since 1968 with scientists in the winter wheat area of the northwest U.S.A. and with the Government breeding program in Turkey, to develop an effective winter-spring wheat crossing program.

The most widely grown spring wheat variety in Canada is the result of a winter-spring cross, and it shows superior drought tolerance. In 1972 a Pakistan breeder announced a new variety, S.A. 42, with superior drought tolerance. It has one parent from a winter wheat.

The achievement of greater drought tolerance in the spring wheats is only one of the objectives of this work, but it is the present judgment of CIMMYT staff that the winter-spring wheat crosses offer the

most likely quantum jump in drought tolerance for the world's spring wheats.

CIMMYT is already circulating very promising nursery materials resulting from winter-spring wheat crosses, but benefits to private farmers are several years in the future.

One additional comment on root structure is relevant.

CIMMYT data show that dwarf wheats developed prior to 1964 had a horizontal type root system, which in conjunction with a short coleoptile (the part of the plant between the roots and the lower leaves) made these varieties adapt poorly to semi-arid areas. Although dwarf wheats developed since 1964 have a deeper root system than their predecessors, CIMMYT is presently distributing experimental populations of wheat with taller segregates, which generally have a longer coleoptile, in an effort to serve the full range of needs in drier areas.

(c) Drought resistance, derived from disease and insect resistance

The damage of drought upon a maize crop is often increased greatly if the crop is already weakened by either disease or insects.

The reverse is also true. Diseases and insects which will not, in themselves, greatly affect the yield of a maize crop, may totally destroy the crop if they occur immediately before or during a drought.

In certain areas of the world CIMMYT believes it can make a significant contribution to drought tolerance of maize by the conquest of stalk rots.

CIMMYT pathologists and entomologists in collaboration with national programmes are working on most major diseases and insects of maize and wheat. This work should benefit farmers who seek stability of yield, and thus a reduction of risk.

(d) Drought tolerance derived from change of plant architecture

CIMMYT has no positive evidence that a change of plant architecture will increase drought tolerance, but CIMMYT is investigatng this possibility in both maize and wheat.

A belief is held by some researchers that certain cereal plants have the ability to curl their leaves during a drought, thus reducing transpiration (loss of moisture through the leaves).

One maize variety in Mexico and one in Indonesia have been said to have this characteristic. CIMMYT is looking into these and any other maize lines which are reported to be superior in drought tolerance.

CIMMYT is also testing in both maize and wheat, a wide range of genotypes against artificial drought (that is, cutoff of irrigation water for different periods of time, and at different stages of growth). Genotypes which show superior drought tolerance will then be subjected to other trials to determine what are the characteristics of the genotype which contribute to this desirable attribute. Once identified, those characteristics would be employed in the CIMMYT breeding programs.

This work on drought tolerance has not proceeded far enough to draw any conclusions on superior genotypes.

(e) Drought escape, by substitution of crop.

There are many farmers in the world attempting to grow wheat in low rainfall areas better suited to barley.

Similarly, there are farmers trying to grow maize in areas of limited rainfall better suited to sorghum.

CIMMYT is working on barley and cold-tolerant sorghum, in the belief that these two crops are better adapted to certain marginal areas.

Recent trials of CIMMYT triticale in India and Ethiopia have reported that triticale survived severe drought in areas where adjoining wheat was killed.

Scientists know that there are much wider differences of drought tolerance between species, than between varieties within one species. Hence, CIMMYT believes the farmer in marginal rainfall areas will need the results of research on barley, sorghum, and triticale. This should reduce risks.

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No. 10: How does CIMMYT study the needs of farmers who want lower input costs and lower risks ?

CIMMYT has managed the Plan Puebla for 7 years, 1967-73. This has been a project to study the methods of introducing new technology for rainfed maize production in an area of 47,000 Mexican maize growers, whose average land holding is 2.5 hectares.

A terminal evaluation report on Plan Puebla is in preparation during 1973.

Secondly, CIMMYT's economic studies unit is now reviewing the experience of four wheat growing countries, and four maize growing countries, whose farmers are adopting new technology. A terminal report will be presented to CIMMYT Trustees in 1974, with recommendations how these studies should affect future CIMMYT programs.

No. 11: Outreach staff: What contribution is being made by CIMMYT staff stationed outside Mexico, that will benefit farmers who want lower input costs and lower risks ?

CIMMYT now has 20 staff members posted in the following wheat and maize growing countries, collaborating with the national production programs:

For wheat:

Turkey, 2 CIMMYT staff

Tunisia, 4

Algeria, 4

Morocco, 2

For maize:

Nepal, 1 CIMMYT staff

Pakistan, 2

Egypt, 1

Zaire, 3

Colombia, 1

These staff members work as part of the national production programs, engaging in research and training.

Over 90% of their research is conducted under rainfed conditions, and is aimed at benefitting the rainfed farmer. Plant selections they

and their collaborators make are reintroduced into CIMMYT's succeeding cycle of population improvement to increase yield stability over a wider range of conditions. Other scientific knowledge gained in the research of the outreach staff is disseminated through the network of maize and wheat scientists for their guidance and use in national programs.

No. 12: Conclusion: Is CIMMYT doing enough to assist farmers who want lower input costs and lower risks ?

CIMMYT believes that its first research priority should continue to emphasize development of technology that will benefit the widest range of farmers. This means CIMMYT will continue to search for wide adaptation in maize and wheat. CIMMYT will continue to develop plant types, which show greater response to moisture and fertility, regardless of the level of inputs.

This type of research will contribute to a stability of yields, and thus to a reduction of risks.

CIMMYT will continue to train research agronomists in Mexico, who can later assist their Governments of Asia, Africa, and Latin America to develop their local agronomic recommendations suitable to the needs of farmers. This can serve all farmers including those who want lower input costs and lower risks.

CIMMYT staff posted to national production programs will continue working mainly in non-irrigated areas. The additional requests which CIMMYT is now negotiating involve countries which are non-irrigated. Therefore CIMMYT's outreach staff, under these circumstances, are working primarily to benefit rainfed farmers.

CIMMYT does not anticipate any substantial increase in the size of its program in Mexico, but will continue to examine its program priorities so as to serve the widest range of farmers.

Community participation in solving problems in agriculture

I have stressed on several occasions the need for paying attention to the generation of community and student participation in areas like pest control, water management, water harvesting and dryland farming techniques. A recent example was the proposal to organise a community-cum- student drive in Eastern Uttar Pradesh in controlling Pyrrilla in sugarcane. While there is little effort or interest in such work in our country, whose principal asset is its huge population. I was fascinated by the tremendous amount of work being done in this field in the United States. I would like to cite a recent example I saw in Television during my visit to Washington.

In forests and orchards in several parts of U.S., there is severe damage by the insect pest, Gypsy Moth. It has been found that the pest spreads to a considerable extent through the vehicles of holiday-makers. The Members of the National Campers and Hikers Association as well as of the National Camps Association have hence decided to participate in a nation-wide gypsy moth detection and surveillance programme. This programme involves detection of gypsy moths through the use of traps containing pheromone (sex hormone) before a car leaves a camping area. Such voluntary efforts would contribute greatly to preventing the spread of this serious pest.

APPENDIX I

DDDR: IAR/73/15 REV. I
June 1973

RESTRICTED

CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

TECHNICAL ADVISORY COMMITTEE

6th Meeting - Technical Advisory Committee

Washington, D.C., 25 July - 3 August 1973

Revised Provisional Agenda

Wednesday - 25 July

09.00 - 13.00 Morning Session, CLOSED

- Item 1. Priorities for International Agricultural Research.
Discussion and formulation of recommendations.

14.30 - 18-00 Afternoon Session, CLOSED

- Item 2. West African Rice Development Association (WARDA).
Discussion of re-formulated proposals.
- Item 3. Conservation of World Genetic Resources.
Discussion of revised proposal.

Thursday - 26th July

09-00 - 13-00 Morning Session, OPEN

- Item 4. Research Needs for Protein Production in Latin America.
Discussion of Report of TAC Sub-Committee Mission.
- Item 5. Research Needs of the Near East and North Africa.
Discussion of Report of TAC Mission.

14-30 - 18-00 Afternoon Session, CLOSED

- Item 6. Formulation of Recommendations on Items 2, 3 and 4.

Friday - 27 July

09-00 - 13.00 Morning Session OPEN

- Item 9. International Soyabean Research.
- Item 8. Research on Tropical Fruits.
- Item 13. Aquaculture - Progress Report.

14-30 - 17.30 Afternoon Session

Participation in the second session of the Socio-economic Research Seminar.

Saturday - 28 July

0.8.45 - 13.00 Morning Session

Participation in the final session of the Socio-economic Research Seminar.

14.30 - 18.00 Afternoon Session, OPEN

- Item 10. Research on Agricultural Mechanization in W. Africa.
- Item 11. Research Programme on Trypanosomiasis.
- Item 12. Research on Pest Control (F'0 proposals).

Monday 30 July and Tuesday 31 July

Joint participation with members of the Consultative Group in Centres Week presentations of the programmes of the International Centres.

Wednesday - 1 August

09.00 - 13.00 Morning Session, CLOSED

- Item 14. International Centres. Discussion and formulation of recommendations of the Centres' Programmes of Work and Budgets.

14.30 - 18.00 Afternoon Session, CLOSED

- Item 14. Continuation and completion.
- Item 15. Formulation of recommendations and conclusions on Items 8, 9, 10, 11 and 12

Thursday - 2 August

Participation in the Consultative Group Meeting and presentation of the Report of the Chairman of the TAG.

Friday - 3 August

09.00 - 13.00 Morning Session

Participation in the Consultative Group Meeting.

14.30 - 18.00 Afternoon Session, OPEN

- Item 16. Any other business.
- Item 17. Date and place of Next Meeting.
- Item 18. Chairman's Summing-up.

INTERNATIONAL CENTERS WEEK

LIST OF PARTICIPANTS

Chairman

Richard H. Demuth

Centro International de Agricultura Tropical (CIAT)

Dr. F. de Sola

Dr. U.J. Grant

Dr. P. Pinststrup Andersen

Dr. F. Byrnes

International Maize and Wheat Improvement Centre (CIMMYT)

Dr. Virgilio Barco

Mr. Haldore Hanson

Dr. D. Winkelmann

Dr. R. Osler

Dr. O. Brauer

International Potato Center (CIP)

Dr. Mariano Segura

Dr. Richard L. Sawyer

Dr. John Niederhauser

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

Dr. C.F. Bentley

Dr. R.W. Cummings

Dr. James Ryan

International Rice Research Institute (IRRI)

Dr. F.F. Hill

Dr. N.C. Brady

Dr. Randolph Barker

International Institute of Tropical Agriculture (IITA)

Dr. H.R. Albrecht

Dr. K. Robinson

Dr. J.L. Nickel

Australia

Dr. Peter Muecke

Mr. S.A. McLeod

Belgium

Dr. C. Populer

Canada

Mr. Ian Robertson

Dr. H.G. Dion

Mr. G. Krivicky

Denmark

Mr. O. Moelgaard Andersen

Food and Agriculture Organization

Mr. J.F. Yriart

Ford Foundation

Dr. David E. Bell

Dr. Lowell Hardin

Dr. Norman Collins

Dr. Dale Hathaway

France

Mr. H. Vernede

Germany

Dr. Werner Treitz

Dr. W. Hermkes

Inter-American Development Bank

Mr. Alfred C. Wolf

Jesus Munoz Vasquez

Mauricio Herman

Thomas F. Carroll

International Bank for Reconstruction and Development

Mr. Warren C. Baum

Mr. M. Yudelman

Mr. James Fransen

Mr. George Darnell

Mr. J. Hendry

Mr. A.A. Neylan

Mr. M. Ruddy

Mr. A. Urquhart

International Development Research Centre

Mr. J.H. Hulse

Mr. A.F.W. Plumptre

Mrs. Wendy Marson

Japan

Dr. K. Shiotani

Mr. M. Sumi

Mr. N. Akao

Dr. N. Kenmochi

Kellogg Foundation

Mr. N.C. Fahs

Netherlands

Baron R.H. de Vos van Steenwijk

Mr. W.F. M. Albers

Dr. G. de Bakker

Professor A. Franke

Rockefeller Foundation

Dr. Sterling Wortman

Dr. John A. Pino

Dr. E. Wellhausen

Sweden

- Dr. A. Willen
- Dr. R. Beijer
- Dr. G.O. Janer
- Dr. M. Nordblack

Switzerland

- Dr. R. Pasquier

Technical Advisory Committee

- Sir John Crawford (Chairman)
- Dr. D. Bonner
- Dr. H.A. El-Tobgy
- Dr. M. Elgueta
- Dr. W.D. Hopper
- Dr. L. Marcano
- Dr. I.E. Muriithi
- Dr. J. Pagot
- Dr. H.C. Pereira
- Dr. V.W. Ruttan
- Dr. L. Sauer
- Dr. M.S. Swaminathan (Deputy Chairman)
- Dr. N. Yamada

- Mr. Peter Oran (Secretary)
- Mr. Brian Webster

United Kingdom

- Mr. W.A.C. Mathieson
- Mr. A.R. Melville
- Mr. R.K. Cunningham

United Nations Development Programme

Dr. I.G. Patel

Mr. W.T. Mashler

Mr. M.M. Gucovsky

Mr. G. Havard

United States

Dr. J. Bernstein

Dr. O. Kelley

Dr. G. Baird

Mr. J. Cooper

Representing Africa

Dr. B.W. E. Anon, Nigeria

Representing Asia

Dr. S. Boon-Long, Thailand

Representing Latin America

Mr. J.A. Del-Aguila, Argentina

Mr. C.R. Mourao, Brazil

Representing Middle Eastern Region

Dr. H. Huque, Pakistan

Dr. Malek Basbous, Lebanon

Representing Southern and Eastern Europe

Mr. G. Cohen, Israel

Asian Vegetable Research and Development Center

Dr. Robert F. Chandler, Jr.

Dr. E.B. Oyar

Dr. T.H. Shen

African Livestock Subcommittee

Mr. L.J. C. Evans (Chairman)

Dr. Barry Nestel

Dr. D. Tribe

Dr. E.H. Sadun

Consultative Group Staff

Mr. Harold Graves, Executive Secretary

Mr. Bruce Cheek, Deputy Executive Secretary

(Mrs.) Audrey Mitchell

Miss Caryl Jones

CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

INTERNATIONAL CENTERS WEEK

PROVISIONAL LIST OF PARTICIPANTS

ADDENDUM

West African Rice Development Association (WARDA)

Mr. Jacques Diouf

Representing Southern and Eastern Europe

Dr. Ioan Precup

Norway

Mr. H. Midttun

production rapidly enough to meet domestic demand has led to increasing imports, draining foreign exchange required for social and economic development. Third, cereals are the lynchpin of the cropping system in many developing countries and contribute significantly to income and employment. Finally, a faster growth of grain production will be necessary if feed supplies are to become available in sufficient quantity at prices which will permit their economic use in livestock rations.

6. While these reasons in themselves offer a compelling argument for devoting high priority to research on the cereals, there is another important consideration. In the past many developing countries increased their production largely by expanding the cultivated area. Analysis of the sources of increased output in the last decade show that for most crops including the cereals, this has been the mainspring of growth in all but a few countries. Certain are still fortunate enough to have reserves of good land which can be brought under the plough, but many are already pressing up against the limits of their natural resources or will be within a measurable time-span; and in some marginal land is already being cultivated with serious backlash effects on pastures, and forests, and consequent environmental degradation.

7. Our problem is therefore one of trying to get more and more from a finite or even shrinking resource. It thus becomes increasingly necessary to turn towards raising yields and crop intensities as the major source of future growth, and since cereals occupy the largest share of the arable area in a wide range of environments, they hold the key to the more effective use of land and water resources. Unless their yields can be increased or their time to maturity reduced, it will be correspondingly more difficult to make significant progress with other crops and livestock since more and more land will have to be devoted to satisfying basic calorie requirements. The alternative - increasing imports - is open only to a few countries.

8. Despite the crucial nature of this problem, major international research programmes until recently covered only wheat, maize, and rice, plus the special programme on Triticale being developed with IDRC help. Sorghum and pearl millet have now been added to the list by the establishment of ICRISAT in India, and the TAC has made recommendations to the Board of ICRISAT as to how effort might also be reinforced on these two crops in Africa as part of ICRISAT's overall programme. Barley, which is of particular importance in the semi-arid winter rainfall environment of the Near East and North Africa, is also under our scrutiny.

9. Nevertheless, it is open to question whether even now enough is being done in respect of cereals, and three aspects seem to merit special attention. The first is the adequacy of outreach programmes of the international institutes working on cereals, and whether these might be linked more effectively to national work by closer collaboration with other agencies such as FAO, IBRD, and UNDP. The second is whether enough emphasis is being placed on protein quality as against further increases in yield. The third is the degree to which yield stability could be improved, particularly in the more difficult environments, by a better understanding of the fundamentals of plant physiology, disease and pest resistance, and population dynamics, possibly requiring further basic research.

10. Turning from cereals to other key food commodities, the TAC has accorded high priority to those which will improve the quality of the diet, especially in respect of protein. In particular it has focussed attention on the food legumes and on ruminant livestock.

(ii) Food legumes

11. The food legumes are the second main source of total protein in the diet, and, at least for the lower income groups, the principal determinant of dietary quality, because they complement the unsatisfactory composition of most cereals in terms of the limiting amino-acids. They are also a potential source of simulated milk and meat products; soya bean is already being developed industrially for such purposes. Again this could particularly benefit the poorer people, especially pregnant women and infants. It could also help to overcome physiological (milk intolerance), customary, and religious obstacles to the consumption of animal protein in developing countries.
12. There are peculiar difficulties in improving productivity of most grain legumes which make international support for research particularly necessary. Yields in developing countries are generally extremely low relative to those legumes grown in developed countries and to other food staples, especially the high yielding varieties of cereals. Moreover, they have shown little improvement over time. While there are numerous pest and also disease problems of varying location specificity, there also appear to be intractable physiological and morphological problems which might impose a low ceiling on yields even if pest and disease control measures were highly efficient. These include indeterminate flowering habit, high rates of flower drop, photosynthetic inefficiency, excessive vegetative growth, residual toxicity to subsequent crops, and so forth.
13. The combined result of the factors outlined above is poor response to irrigation, fertilizer, and other inputs which renders their use on legumes unrewarding to the farmer. This accounts for the shrinking area of pulses in relation to cereals in a number of developing countries; nutritional value counts less than profit with the producer, and with the advent of the high yielding varieties of cereals - often bolstered by price supports - comparative economic advantage is clearly with the latter.
14. While recognizing the importance of these crops, the TAC has been grappling with the problem of how (if at all) to reconcile the apparent need for centralised basic research on factors holding down yield common to several species of grain legumes, with the large number of species having no ecological common denominator with which any centralised facility would have difficulty in coping. Moreover, even if solutions could be found to this ecological diversity (through the use of controlled environmental chambers, etc.), enabling research on problems of a more fundamental nature to be undertaken centrally, there would still be location-specific pest, disease, parasitic and end-use questions requiring adaptive research.
15. This problem has not yet been satisfactorily resolved. The TAC has recommended support for breeding and applied research programmes on cowpeas at IITA, field beans (Phaseolus species) at CIAT, chickpeas and pigeon peas at ICRISAT. It is examining a proposal from U.S.AID for strengthening outreach programmes and tropical testing on soybeans, using the great United States experience in this crop as a resource base. However, no internationally supported applied research effort is in progress on groundnuts, broad beans (Vicia faba), lentils, field peas, and certain other important or potentially important tropical and sub-tropical legumes. Nor has a decision been reached as to whether a central basic research effort is justified.

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16. The Secretariat has been asked to study the state of the art further, with consultant advice, and to report its conclusions to a special TAC sub-committee on food legumes. The latter will also review and recommend on any proposals coming to TAC from the international research institutes or elsewhere for additional applied research on these crops.

(iii) Starchy products

17. The third major group of food crops to which the TAC has accorded high priority is the starchy foods including roots and tubers. These crops, despite their nutritional drawbacks are of great dietary importance in the developing world - they are the basic staple of some 80 million people in equatorial Africa, for example. They have a potential for producing an enormous output of energy per hectare, and their yield, nutritional quality, and range of adaptation all appear capable of improvement. Yet, as was pointed out at the 5th TAC meeting in 1973, they have received much less concentrated research attention than the cereals, since only the potato is of significance to developed countries.

18. The TAC has therefore recommended continuing support for work on cassava at CIAT and yams and sweet potatoes at IITA, as well as the expansion of ongoing efforts on potatoes in Peru and Mexico to form a new International Potato Centre with the same broad charter and base of financial support from the Consultative Group as the other international centres.

19. The edible plantain is now the only important member of this group of crops remaining outside any major research programme, despite a proposal by IITA that exploratory work should be included in its programme for 1973.

(iv) Livestock

20. In respect of livestock the TAC has taken the view that priority should go to the ruminants. While there are greater constraints on a rapid increase of ruminant production than apply to pigs and poultry, there is also a great potential for better resource utilization by ruminants which conflicts only to a limited extent with requirements for land for direct production of human food. Moreover, ruminants are of dominant social and economic significance in some of the poorest and most backward countries which have little scope for other agricultural development, for example in the Sahelian zone of Africa, and where knowledge acquired in developed countries cannot easily be transferred successfully. Conversely pig and poultry production can be increased most easily by sophisticated, capital intensive methods which depend less on research than on the application of western style technology, with entrepreneurship and sound managerial ability as critical factors.

21. As you know, a first step has been to recommend support for the establishment of additional facilities to work on certain limiting problems of animal disease in Africa (with priority to Trypanosomiasis and East Coast Fever); and, more or less in parallel, to set up a new institute to work on the improvement of animal production there. A main focus of the latter will be to study the predominant systems of livestock production in Africa as a means of determining the key bottlenecks as well as the opportunities for the introduction of new technology within each system.

22. This approach is to an important extent a reversal of the procedure adopted by some of the older international centres, which started by focussing on achieving a technical breakthrough on a rather narrow front, and have only recently placed greater emphasis on trying to influence traditional systems to accommodate this new technology. There are arguments in favour of both approaches, but that proposed for the animal centre is an innovation which we shall all follow closely.

23. These are the first major livestock enterprises which the TAC has recommended to the Consultative Group for support; they are unlikely to be the last. There are interesting developments in South-East Asia, focussed initially on Indonesia, in which Australia, through CSIRO, is playing an innovative role. The TAC is examining means of strengthening work on beef in Latin America, and it is probable that the improvement of livestock production through the closer integration of crops and ruminant animals will figure largely in any proposal for work in the Mediterranean/Near East region. Both these proposals of necessity also involve improved range and pasture management.

(v) Aquaculture

24. One other possible means of increasing supplies of protein lies in aquaculture. New and more scientific methods of farming fish and other aquatic creatures are evolving rapidly, although so far these do not appear to have had an impact on domestic food (or feed) supplies in developing countries so much as in increasing export earnings.

25. The TAC is holding a seminar in July 1973 to try and inform itself on the potential for mass production of cheap food from aquaculture, the state of the art of research, and whether reinforcement of existing efforts might be effective in generating a new breakthrough in productivity.

II. Second-Level Priorities for Food Research

26. Having taken a firm position on its priorities for cereals, food legumes, roots and tubers, and ruminant livestock (especially cattle) and placed a temporary question mark against aquaculture, the TAC has been less decisive on some other foods, in particular oilseeds, vegetables and tropical fruits. This is partly the result of pressure of work related to the commodities listed above, which, it decided in its earliest session, were of highest priority, and where some good projects were already in the pipeline, but it also reflects a lack of sound proposals for research on other food commodities.

27. Another important constraint has been the inadequacy of statistical data concerning production, consumption, and dietary significance to lower income groups of some of those commodities, in particular vegetables and fruits. These are appallingly bad in most developing countries (perhaps only those on pastures, fodders, and fallow are worse), and there is a strong case for more research at the national level to improve the information base on which to judge their nutritional importance and economic value. While this might be supported indirectly by the CGIAR as part of some wider effort in socio-economic field, it should also be given more attention by international agencies such as FAO and the Bank.

28. This having been said, I am still unsure what rating the TAC would give to a good, well formulated and documented project for research on one or more of such crops. The Asian Vegetable Research Centre proposal was perhaps the first test case, and although there are reasons why this cannot be considered a fair precedent, there were also doubts in members' minds both on the technical feasibility of working successfully on such a wide range of crops and concerning their contribution to the diets of poorer people.

29. In approaching such commodities we therefore have in the first place to try and achieve a balanced view as to their importance both globally and in relation to particular regions - since what may be of great weight in one tropical area may be of smaller significance in another. Then we have to assess whether the proposal itself seems feasible and likely to lead to an impact-making result within a measurable period. Both pragmatism and judgement are required and I do not believe the TAC should be expected to go further in relation to this wide group of "other foods" at the moment than saying that while it rates them as of second importance to the food staples and might not initiate research proposals itself, it would be willing to give careful consideration to well prepared specifics.

30. In this connection some members of TAC felt that where a clear research need was identified on some crops or projects before it, but which it did not consider of top priority for Consultative Group support, the Committee might recommend these as deserving of bilateral or other assistance, e.g. from UNDP or the Bank. This is not meant to imply that the TAC can act as a general screening mechanism for bilateral agencies in relation to projects of a purely national nature. While we attach the greatest importance to a strong national research base, other agencies than CGIAR exist to assist here, and any projects submitted to TAC by the Co-Sponsors or members of the Consultative Group must have genuine international or regional connotations.

111. Research on Other Agricultural Crops

31. A rather similar pragmatic approach to that for some of the less important food crops may have to be taken for the time being to those crops variously described as "non-food", "industrial", or "Agricultural raw materials". We do not have a satisfactory generic name for this widely diverse group, some of which (such as cotton) have multiple uses for fibre, food, and feed.

32. So far no specific worked-out results for support to research on these crops have been submitted to TAC, although mention was made at our last meeting of the need for an internationally backed research programme on jute in Asia. While members regarded this suggestion sympathetically, mainly because of the official economic and social problems facing Bangladesh, it was felt that it was more suitable for bilateral funding because of the relatively few countries which would benefit. There were also doubts as to whether the position of jute vis-a-vis synthetics could be restored even if a major investment were to be made in research. It was also felt that the time might not yet be ripe to recommend support for non-food crop, while some important food commodities and food producing areas were still not receiving adequate research.

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33. At the same time the TAC did not preclude its future consideration of well prepared proposals for priority lines of research on other commodities, provided that the over-riding need to secure the staple food supplies of the mass of the people was first covered by existing or new international and regional research programmes.

34. This seems to me a logical approach, since not only nutrition but also income, employment and foreign exchange earnings are essential goals of developing countries. Lack of purchasing power is as critical a cause of malnutrition as problems of food production. Moreover, shortage of foreign exchange may be a key constraint on the supply of inputs required to raise food output.

35. However, there is a large range of such crops and their claims compete with each other and with other priorities, especially food production and nutritional research, for limited funds. There is a real need for an "overview", which takes into account their current economic and social importance, their market potential, the effectiveness of ongoing research, the potential for useful additional research, where the main thrust of this should lie (i.e. in production, processing, or end use), and its probable cost.

36. This should enable the TAC to weed out the more obvious non-starters, e.g. crops with inelastic demand, crops which benefit relatively few nations and/or producers, crops being hopelessly outpaced by synthetics, and those where research is already adequate.

37. In some cases where further research was required it might be shown that appropriate reinforcement and "internationalisation" of an outstanding national institute would yield large dividends at relatively small expense. This, of course, would imply the willingness of the institute and country concerned to share its results and material outputs (e.g. breeding materials), with other countries. This has not always been the case in the past. More difficult problems of choice may arise if costly end-use research is indicated as the real need, since this might have to be done in a developed country with sophisticated industrial resources.

38. - FAO is considering undertaking this review during 1973 with the help of a consultant, as a joint effort between its Commodities Division and the Research Development Centre. We will await the outcome of this analysis with interest.

IV Forestry

39. The only major group of commodities I have not yet mentioned are the forest products. The TAC has so far had no specific proposal to support research in forestry, although the possibility of establishing a tropical forest research institute - probably in South-East Asia, has been mooted. This will be considered on its merits, but members' initial reactions to an outline paper indicated that their main concern related to research on the role of forest cover in the conservation of the environment rather than to timber production and processing.

40. Perhaps this may be too narrow a view and research should be focussed on making timber production, forest regeneration, and soil and water conservation more compatible. After all tropical forests represent one of the few promising and relatively untapped sources of economic wealth in a number of tropical countries. This resource will be exploited, but whether the end point is a sound, renewable forest rotation or a ruined watershed may depend on well integrated and imaginative research ex ante.

V. Factor-Oriented Research

41. This is perhaps an apt point to discuss another somewhat controversial issue of priorities. So far the TAC has preferred to express its goals largely in terms of commodities, and this certainly has the merit of clarity and easy definition. At the same it has also had before it certain proposals for research related to what might best be defined as factors of production (water use and management, integrated pest control, pesticide residues, etc.) which have caused it some difficult moments.

42. In general, members have taken the view that such problems are most meaningfully studied in relation to specific commodities rather than as ends in themselves. They have argued that one of the reasons for the success of the rice and wheat programmes has been the realisation by IRRI and CIMMYT of the need to develop and present to the farmer an integrated "package" of technology appropriate to their new varieties, and not just the latter in isolation unsupported by other essential inputs.

43. There is much merit in this argument, but there are nevertheless instances which can be identified where it may be an inadequate approach. Except in monocultures, water use and management systems have to be related to the crop-mix rather than to the individual crop; fertilizer and pesticide residues contributing to environmental pollution again come from the totality of the farm and not just one enterprise. Multiple cropping depending on high output per annum involves radically different management and plant breeding and cultural concepts than systems which depend primarily on high yield per individual crop. Tubewells have contributed significantly to the Green Revolution, but has research been adequate on the aquifer on which they depend for their continued existence? Storage, and control of certain causes of crop loss, e.g. rodents, may present problems of a broader nature than a single crop.

44. Some of these issues are important, and I raise them not at all to call in question the correctness of the TAC's approach to date, but as a cautionary note to the Consultative Group that it should be prepared to look sympathetically at departures from the conventional type of commodity-oriented package programme type of research which it has mainly been called on to support so far.

VI. Research on Intensification

This caution may well apply to the approach required to improve agricultural production in the Near East and North Africa, where the major food crops, except barley and broad beans, are already covered by the work of existing institutes, and where the need is not so much to raise the yield of a single crop as to intensify agriculture and increase productivity through better resource utilization. The concept of high yields per individual crop which has so far dominated the goals of the older institutes may have to be subordinated to one of maximizing the use of scarce resources - in this region generally water.

46. This involves such problems as the better integration of crops and livestock, the substitution of the fallow which now occupies 60 percent of arable area every year by fodders in the wheat-fallow rainfed rotation along the lines followed in the analogous climatic zone of Australia; change in cropping patterns in irrigated land to optimize income and

employment; and the creation of a stratified pattern of livestock movement from rearing on the range to fattening on arable land or in feedlots. Work on individual food crops, especially cereals and grain legumes, will remain important, but the main focus would be on developing more productive systems which might also include livestock, non-food or forage crops.

47. Research on the socio-economic as well as the physical constraints to increasing productivity and developing integrated land use assumes great importance wherever work has to be undertaken on transforming traditional farming patterns and developing complementarities across ecological or social boundaries, whether in West Africa, "upland" cropping areas of Asia, or in the Near East and North Africa, and there may be correspondingly greater difficulty in finding a suitable institutional formula for such studies than for more narrowly commodity-oriented research.

48. But the ultimate objective of agricultural research is development, not just increasing yields, nor even such a straightforward goal as increasing food production. We must not be so bewitched with the hopes of further spectacular successes with single crops that we fail to recognize that other pathways to growth may exist. In some regions, for ecological, social, or economic reasons, research of a broader nature - even if it appears more complex, may offer the better hope of a solution. Where such an approach seems desirable the TAC and the Consultative Group must grasp the nettle boldly.

VII. Socio-Economic Research

50. Discussion of these broader issues leads rather logically to a consideration of socio-economic research. Here the TAC has recognized three levels of action i.e. :

- (i) research at the micro-level (farm or village community), to identify the socio-economic constraints to the successful adoption of new technology, and to guide scientists at the international institutes and elsewhere as to the types of technology most likely to be acceptable to farmers.
- (ii) research at the level of public policy, e.g. to determine the measures and incentives needed to accelerate the use by farmers of technical innovations, to give early warnings of possible "second generation" effects of such innovations, e.g. on employment or prices, and to illuminate the choice of alternatives.
- (iii) research at the macro-level on broad issues affecting more than one country, or the economy of a country as a whole, e.g. on commodities and trade, some aspects of nutrition, sectoral analysis, etc.

51. The adequacy of current research at each of these three levels was debated at length at TAC's fifth meeting, following introductory papers by economists from the international institutes and from FAO's Economic and Social Policy Department.

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(i) Micro-level research and the role of the international institutes

52. The Committee was impressed with the general approach at the micro-level being followed by the institutes, This applies both to their socio-economic studies, and to their cooperation with other disciplines aimed at the identification and solution of specific problems not of a purely economic nature, such as improving water management in paddy rice, or mechanization. Members felt that serious consideration must be given during Centres Week discussions to reinforcing the socio-economic staff of the institutes.

53. Members saw the work of the socio-economists at the institutes as having particular value in defining the parameters of a problem in collaboration with other scientists (e.g. with agro-climatologists in identifying the importance of upland rice), in providing guidance as to whether a new technology was likely to be capable of adoption by producers in their existing farm situation, and in helping the programme development and allocation of resources to research at their institutes. Clearly such information would also be of great assistance to TAC.

54. Doubt was expressed, however, as to whether the results of the micro-level research programmes per se of the institutes could have widespread application because of their location specificity and the impossibility of providing tailor-made solutions to the wide range of situations existing in countries covered in the institutes' terms of reference. Members also doubted whether the institutes could play as effective a role in influencing public policy as they could in micro-level research, since their relatively narrow focus, although a source of strength in approaching problems at the farm level, limited their scope for offering guidance on broader issues.

55. Concern was expressed by several members at the disparity which appeared to exist between the rather considerable resources now being channelled to the analytical case study type of socio-economic research being undertaken by the institutes, valuable though this was, and the weakness of national systems which were being expected to undertake complex studies on such key policy issues as optimum size of farm; employment, urban migration; land reform and other problems consequent on the choice of various technological alternatives; investment strategies for agriculture, the mobilization of savings and capital formation in rural areas, price policies, etc. Attention was also drawn to the need for information on which to assess the results of large-scale development projects, the acceptance of new techniques, reasons for their success or failure; and the impact of different forms of investment, e.g. irrigation, infrastructure, etc. on agricultural employment, and general economic growth. This was a much broader field of socio-economic research than was currently being covered by the international institutes, and it was felt that while the latter were strongly equipped to study individual components of the agricultural structure in a local environment, they could not be expected to provide the integrated approach at the national level which was required for the solution of broad policy issues.

56. There was a strong feeling that this dilemma could only be resolved by channelling more resources to helping the developing countries to build up their own capacity to undertake socio-economic research both at the farm and the policy level.

57. In this process the international institutes could play an important role through the development of generalised methodology (e.g. for the study of production functions) and the construction of flexible models (e.g. on farming systems) capable of wide adaptation by national institutes; in the training of national workers (including scientists and planners) to use and understand the socio-economic technology and to enable them to cooperate in multi-disciplinary research; and in the assembly and analysis of information and the dissemination of the results of socio-economic research to other research workers. The general trends emerging from the institutes' own research might also be of value to policy makers outside their host country, even if the detailed conclusions might have more localised applicability.

(ii) Research in relation to decision-making in public policy.

58. Despite the value it placed on the work of the institutes at the micro-level, and its recognition that a number of the macro-level problems were being increasingly well catered for by FAO, IBRD and other international bodies, the Committee was conscious of a gap at the intermediate level of public policy.

59. This takes two forms: first a weakness in communication of the results of micro-level research to national planners and politicians; secondly, a failure of research to cover key policy issues. In some cases the latter concern commodities not covered by any international centre; more often they relate to problems of the type referred to in para. 55, the solutions to which lie beyond the scope and terms of reference of the centres.

60. Because of its concern, the TAC discussed the possibility of establishing some special internationally supported institution to coordinate and stimulate work on problems of this nature, to improve information services to policy makers and to train national cadres. A majority of members was against the idea of any central body, not because they saw no need for reinforcing national action in such matters but because they did not believe it was a workable proposition.

61. An intermediate approach worth further consideration is that of a "travelling seminar" which would be focussed on a problem of known importance identified by the TAC or some other suitably qualified body, and which, after a preparatory period of desk study by its organizers, would examine the problem on the ground and conduct seminars at a number of selected sites. Such a group could be of a multi-disciplinary nature, with representatives from both developed and developing countries, and its conclusions and recommendations would have relevance not only to the work of the TAC and CGIAR, but to the international centres and agencies, and to policy-makers at the regional and national level. It could be particularly valuable as a means of providing linkages between national centres, especially in the weaker, inadequately equipped countries.

62. There is clearly plenty to do both in research on policy orientation and in improving the effectiveness of communications on research to the policy makers. The issue is not so much what to do as how best to do it; and here the TAC has so far been unable to make a definitive judgement.

63. However, it is certainly the intention of TAC to resume its debate on these questions, and the ideas indicated in paras. 50.6 should therefore be regarded only as an interim summary of its views. We hope that the U.S. AID sponsored seminar to be held in July in conjunction with International Centres Week will take us further along the road towards a positive recommendation to the Consultative Group.

VIII. Institutional Approaches to International Research

64. So far the TAC has adhered rather closely to supporting institutes along the classical lines represented by IRRI or CIMMYT, and these are still the model which seems most apt for commodity-package oriented research.

65. Nevertheless it is undeniable that large multi-disciplinary institutes are costly to establish, expensive to run, and hard to disengage from or to alter the course of if they cease to be highly productive. This has led to doubts about continuing to add to their number, and to a search for other institutional approaches to international or regional research which are cheaper or more flexible.

66. There is a need for perspective in this matter. The capital and running costs of the institutes, although high by standards of research establishments in most developing countries, are considerably lower than those in some developed countries. They also compare favourably in cost and (in the case of IRRI and CIMMYT) the speed of flow of benefits, even with fairly small irrigation projects. The newer institutes have not really had time to prove themselves. So we must not hesitate to recommend other large or complex institutes if we believe this to be the correct approach.

67. On the other hand, the alternative approaches so far attempted usually involving some kind of research network with several countries cooperating according to an agreed programme, have not generally achieved outstanding results. (FAO's Near East Animal Health Institute may be an exception, but it is not strictly a research network.)

68. Again, the fact that there have been few resounding successes should not deter us from innovative approaches where these seem to offer a viable alternative to establishing some new large institute. The WARDA programme is our first test case and this is why we are devoting such careful attention to its proposals and to measures designed to facilitate its success.

69. Perhaps I should emphasize here that I do not consider it meaningful to attempt to distinguish between a "global" or "international" institute and a "regional" one, in the sense that the former would be valid for TAC/Consultative Group consideration and the latter not. This is mere semantics: IITA and CIAT are both essentially regional institutes, although they claim "global" Responsibilities for the improvement of certain crops. As I said earlier some "regional" research problems may affect more human beings than others of a "global" nature. It is the importance and validity of the research proposed which should determine our willingness to support a given programme with international money within the limits of finance likely to be available.

IX. Strengthening National Institutions.

70. A problem with which TAC has not yet grappled adequately is how to strengthen national research institutions. This is perfectly understandable in the light of its terms of reference and its heavy workload related to international and regional research. Yet a strong national research capability is essential to the ultimate success of our investments in "international" research as well as to enabling developing countries to deal with localised problems not being touched on by the work of international institutes. I should therefore like to share with you a few ideas on this subject even if they have not yet been discussed in any detail by TAC.

71. What I have to say is not to be construed as a criticism of the international institutes, which are doing a most valuable job in training, seminars and information, as well as in their outreach work. However, this may not be enough. Already with ICRISAT's work, with WARDA, and in the case of the African Livestock Institute, we are having to face up to questions of how existing stations in developing countries can be used not merely as part of "outreach" effort, but as an integral part of the programme of internationally supported research institutes.

72. To further this objective the Consultative Group may have actually to put money into national institutes, although this would probably not involve support to their "core budgets" but rather "special programmes", with outposted members of international staff working alongside national staff, or in appropriate cases sub-contracting to national institutes.

73. The proposal for establishing a world-wide network of international, regional, and national stations working on the collection conservation and evaluation of genetic resources, which TAC has always strongly supported, will also help to strengthen national programmes; in a few cases by establishing regional genetic resources centres in the regions of main genetic diversity of major crops, but also by enabling countries to participate in exploration and collection missions and to share in the pool of world genetic resources more equitably. It is encouraging that FAO has agreed to support the crucial coordinating centre from its regular programme resources, and that some members of CGIAR are evincing interest in supporting regional centres.

74. Nevertheless while providing important elements of reinforcement to national programmes these measures touch only the fringe of the problem. There are hundreds of agricultural research stations of one kind or another in developing countries, at widely differing levels of excellence. Our knowledge of what they are doing and how well they are equipped and financed to do it, is weak. This has been an obstacle to the TAC's decision-making process, and even the field missions sent out by it and by the Consultative Group have found difficulty in making an adequate evaluation of what is already going on.

75. This was a main reason for TAC recommending support for a pilot study of FAO's CARIS project; and during our priority discussions several members rated the collection and dissemination of research information as an important item. Support from Consultative Group members in one form or another for the CARIS pilot project has increased and FAO are hopeful of delivering the

directory in two languages and based on three different storage and retrieval systems (SSHE, CRIS, and EEC) by November 1973. This will then be subjected to independent evaluation with the help of IDRC, as a basis for a recommendation to the TAC as to follow-up action.

76. I am not prepared to pre-judge these conclusions, apart from saying that a more comprehensive view of existing research establishments and ongoing research programmes in developing countries ought to be of considerable value to the TAC and the outreach work of the international institutes, as well as providing the basis for exchanges of ideas and materials between the developing countries themselves.

77. Most important of all it should indicate to national governments (by comparative yardsticks) and to aid agencies working with them, where the need for reinforcement lies or how existing resources might be regrouped to work more effectively. In the last analysis this is a national decision, although the international institutes and agencies like FAO and UNDP can offer guidance and help in developing appropriate information, training and other linkages. It may, however, be legitimate to query whether the resources being devoted by FAO, UNDP, and the Bank to this important activity are adequate, or whether sufficient weight is being given to strengthening national research and extension services in the UNDP country programming exercises. The tempo of financial assistance from IBRD, UNDP, and bilateral donors for developing national research capacities might well be raised. This matter really falls outside the TAC's competence, but it might be able to assist by fielding travelling missions to look at country establishments and needs, although if it were to do this it would certainly require additional financial resources.

78. This brings me to a further question. How far are the results generated by international research programmes being incorporated into FAO/UNDP or IBRD investment or pre-investment projects? This might not only increase the benefits but also reveal the snags of new technology within a broader environment than the individual farm, and help devise the development process? CIMMYT attempted this in their Pueblo project, which is now being phased out, and it is legitimate to question whether such projects really ought to be undertaken by the institutes themselves, given that their major task is research.

79. Nevertheless, there does seem to be a real need for what FAO in its SOFA chapter on research calls "linkage projects", which would provide an important feed-back both to national policy makers and to the international centres. It may be worthwhile TAC discussing this at a future meeting. This is not necessarily to suggest that the Consultative Group would be asked to fund such projects, but to offer guidance to agencies which might, and to provide moral support for their doing so.

X. Relations Between Applied and Basic Science - "Breakthrough" Research

80. I should like to turn now to an issue at the other end of the research spectrum, but again one which the TAC has had little opportunity to debate so far: is there sufficient interaction between applied agricultural science and basic research? Very few developing countries have the capacity to undertake fundamental studies, and

∠ solutions. Put in another way, how can we broaden and accelerate the input of research into

even the international institutes do not claim to be doing so.
1/ This question appears even more pertinent when one considers that a main criticism of the USDA research programme by the recent National Academy of Science policy review committee was that grossly inadequate support was being given in the allocation of resources to the basic sciences which underpin agriculture.

82. However, there are some - Egypt, Korea, Taiwan, parts of India, where yields and cropping intensities are outstanding even by world standards, and which are beginning to press up against the limits of their natural resources in the light of current available technology. Where do they go from here ?

83. In other countries yields may be low because of ecological constraints which might be alleviated by better understanding of the fundamentals of crop physiology, or because transport costs are too high to make the use of fertilizer economically attractive. The transference of the nitrogen-fixing mechanism from legumes to cereals could transform this sort of situation at one stroke.

84. It is increasingly being asked whether, in terms of environmental degradation and the use of dwindling world reserves of fossil fuels and other natural resources (phosphates), the "high yield" technology is the road not to progress but to disaster. However much one might question the validity of this argument in respect of the desperate immediacy of feeding developing countries there is a need to give more weight to biological methods of control of pests, pathogens and rodents, as well as to new approaches to plant nutrition, including recycling of organic human and animal waste products. Research into methods of monitoring residues, etc. which can be easily applied by developing countries is also needed. The fact that we have so far devised no technology capable of maintaining productivity without high use of manufactured inputs does not mean that we should not search for one.

85. It may be that sufficient work along the right lines is going on in developed countries. the trouble is we do not know enough about it. At a different level of research the information situation is analagous to the problem referred to earlier with the developing countries. Some formal links are being established between institutes in developed countries and the international institutes on agreed lines of research such as Triticale, protein bio-assay, etc. But these do not amount to a systematic approach.

86. A first step might be for the TAG or a "Bellagio" meeting to try and identify some specific objectives aimed at scientific breakthroughs on which "mission-oriented" basic research ought to be focussed on behalf of developing countries. An attempt might then be made with the help of the developed countries on the Consultative Group to identify the actual work in hand on these objectives and the state of progress. If there were

1/ Proceedings of CIMMYT's Board of Trustees, circulated since these notes were drafted, show a similar concern with this matter.

any signs of a breakthrough from ongoing research the question would then have to be asked whether it needed reinforcement and, if so, how much it might cost to achieve success in a measurable time and how the necessary funds might be mobilised. Alternatively, if no adequate research was being undertaken, consideration would have to be given to its being sponsored. A hundred million dollars might seem a lot of money to achieve an historical breakthrough in agricultural science; it is still small compared to public or private research expenditure on many less worthwhile objectives.

XI. Financial Considerations.

87. Any proposal for international support to research or related activities carries financial implications, usually of a long-term continuing nature, and involving both capital and recurrent expenditure. The TAC has been very conscious that the resources of the Consultative Group are not unlimited, and this has been a main reason for its anxiety to define a framework of priorities.
88. In so doing we have had to consider whether to ask the Consultative Group for a financial framework within which to work (amounting virtually to some concept of targets or ceilings), or whether to work on the reverse assumption. This is that sound and worthwhile research projects aligned to agreed priorities will attract financial support from members of the Group and that the job of the TAC is to identify such projects - and to inform the Group of their financial implications, leaving it to the donors to decide what to finance. This, of course, does not mean that TAC should be irresponsible in its judgement as to what constitutes "reasonable" costs of any project which it recommends, or that it will envisage more than a relatively modest annual addition to the research already being financed by the Consultative Group (plus due allowance for inflation). It does, however, imply that TAC will not have to be continually looking over its shoulder because of some rigid financial straitjacket.
89. Most members supported the second course, and this leads to a conclusion that for the continuing support of ongoing international research institutes, and other new programmes judged worthy of support from the CGIAR around \$ 80 million will be required by 1980. The detailed computations are annexed.
90. These estimates take into account the core budgets of the six established institutes (including ICRISAT), as projected by the Bank to 1977, plus a further factor for inflation at 6 percent from 1977 to 1980 (assuming more or less static staff complements by 1977). They also allow for the increase in "outreach" programmes which seems inevitable if there results are to be more readily adapted by national research workers, and more speedily adopted by farmers.
91. Expansion of the programmes of existing institutes will be relatively small; mainly an expansion of IRRI's activities from irrigated rice to the various types of rainfed rice, and to research on cropping systems built around rice.
92. Major new activities envisaged include the African livestock and ILRAD enterprises; and a strong research thrust aimed at increasing the productivity of agriculture in the Near East and North Africa. You will have the reports of these missions before you and I do not need to enlarge

on the approaches proposed, except perhaps to say that they are both a departure from previous precedents in the sense of being systems and development oriented (across as well as within ecological zones); and not focussed principally on genetic improvement of one or two commodities.

93. In addition to these large-scale involvements further action is envisaged in respect of the plant genetic resources, WARDA and CARIS projects, and in the field of protein production in Latin America. A contingency reserve is proposed to support possible new activities which cannot yet be considered as firm. These might include, for example, aquaculture; research on selected "second-level" priority crops both food and non-food; tropical forestry; pest and disease control; water use and management; crop/weather relationships and so on. It is conceivable that some of this might be supported jointly by the Consultative Group and the Environment Fund. It is also conceivable that TAC might want by 1980 to recommend support for research on some new activity such as unconventional sources of protein, which it is not even thinking about at the moment. However, clearly I cannot give you guidance on matters requiring second sight.

94. Two questions remain. First, would developed countries be spending enough on international agricultural research in support of the developing countries in the light of the tremendous stakes involved, even if their contribution were to be \$ 80 million by 1980? Secondly, how do we ensure efficient management of the resources which are put at our disposal?

95. The first question obviously involves political decisions as to the total resources which any developed country can commit to aid, and what share should go to agricultural research and extension within those resources. This judgement is not a matter for the TAC, but I must stress the need- once resources are committed - for a reasonable assurance of continuity from donors as long as there is a clear indication of a pay-off.

96. This brings me to my second (and final) question: what role could (or should) the TAC play in assessing the continuing validity of the overall research programmes of institutes being supported by the Consultative Group. So far we have mainly been asked to look at additive proposals, but in the last analysis it is the disposal of resources within the whole effort which determines its impact. There is a need to prune as well as to encourage growth, and to maintain flexibility to shift resources both within and between research centres rather than always having to add to the overall programme to meet a new challenge. There is a constant danger of petrification of research unless it is kept under a reasonable degree of independent review.

97. However, if TAC were to have to undertake this task it would mean its accepting executive functions. It might then be regarded as both judge and jury, and the confidence of the institutes in the impartiality of its judgements might ebb. I am not in favour of the Committee accepting executive responsibilities, since this would both alter its nature and imply increased staff and commitments, but the members of TAC are not unanimous on this issue. Some feel that the Committee cannot do its job adequately without closer involvement with programme reviews.

Annex 1(a)

GLOBAL ESTIMATE OF FINANCIAL SUPPORT REQUIRED FOR *
INTERNATIONAL RESEARCH ACTIVITIES 1973 - 1980.

Item	U.S. \$ million		
	1973	1977	1980
Six existing international centres ("core" costs)			
1. CIAT	3.50	4.56	5.45
2. CIMMYT	4.85	6.24	7.64
3. CIP (outreach/training component shown under Item 8)	1.04	1.52	2.03
4. ICRISAT	1.20	4.46	5.31
5. IITA	4.55	6.55	7.91
6. IRRI (includes new cropping systems proposal in 1977 and 1980)	2.66	4.52	5.32
	17.80	27.85	33.36
<u>Sub-total "core" recurrent costs</u>			
7. Capital expenditures, six centres	4.60	1.75	3.50
8. "Outreach" programmes, six centres	4.68	7.00	10.00
	27.08	36.60	46.86
<u>Total six existing institutes</u>			
9. Agric: Res: Inf: System (Caris project)	.12	1.00	.30
10. Technical Advisory Committee (TAC)	.16	.22	.27
Total 1973	27.36		
<u>New projects approved or under scrutiny "Core" and "Outreach"</u>			
11. African Livestock Centre (ILCA)		3.23	6.30
12. African animal disease lab: (ILRAD)		3.05	3.50
13. African ICRISAT linkages		1.00	1.22
14. West African rice research (WARDA)		1.20	1.50
15. Latin American beef and legume programmes		.15	.30
16. Research needs Near East/N. Africa		2.00	3.20
17. Soya bean improvement (INTSOY)		1.90	2.50
18. Crop genetic resources network		1.15	1.60
19. Other possibilities not costed		2.00	4.00
20. <u>Capital estimates for new projects</u>		7.00	7.50
Totals 1977 and 1980		60.50	79.05

Notes on items listed in Annex 1 (a)

* The global estimate shows ALL estimated costs of supporting existing and possible new international research activities; whether these have partial funds "in sight" from members of the Consultative Group or not. Where an advance commitment has been made to provide some of the necessary funding (e.g. USAID to INTSOY, the three co-sponsors to TAC, or FAO to the genetic resources network), this is taken as a normal donor contribution to the project and has not been deducted or shown separately. The only items not included in the total are the "earned incomes" of the existing institutes which do not originate from any donor.

Items 1-6: "Core" costs include "restricted and unrestricted", and are taken from the 1973 budget submissions of CIMMYT, ICRISAT, IITA and IRRI, and the 1972 budgets (1973 estimates) of CIAT and CIP. Inflationary allowances are not always specified by the institutes, and where they are not these have been calculated on the basis of the increase in costs between 1973 and 1977 of programmes showing no increases in staff numbers. The same rates have been used for projecting inflationary increases between 1977 and 1980. These are CIAT 6%, CIMMYT 7%, CIP 10%, ICRISAT 6%, IITA 6½%, IRRI 5½%. (An assumption of a steady level of inflation may, however, be optimistic on current trends).

Item 7: Taken from budget figures for 1973 and institute's projections for 1977. No figures are available for 1980 but the figure has been raised substantially over 1977 to allow for inflation and some recapitalisation.

Item 8: Taken from budget figures for 1973, and projections for 1977. In both 1973 and 1977 these amount to some 25 percent of core budgets. An allowance of 30 percent overall has been made for 1980 to allow for increases in the outreach work of CIAT, CIP and IITA, and a beginning of ICRISAT's outreach. It is assumed that CIMMYT and IRRI will maintain their present ratios of around 38 and 48 percent outreach to core expenses.

Item 9: The GARIS "pilot" project already being supported by CGIAR is expected to complete by November 1973. On the basis of an independent evaluation a decision will then be made as to whether to recommend support for the global project or not. The estimate for 1977 shows partial costs of undertaking this project (estimated \$2½ million over 3 years); 1980 costs would be for updating.

Item 10: TAC increases based on 7% compound annual rate of cost inflation from 1973 expenses of around \$160,000.

All items 10-18 assume this rate of cost inflation on recurrent costs, additional to any programme increases. They also include "outreach" cost where shown in project proposals, i.e. ILRAD and INTSOY. In fact these are relatively small, (\$ 750,000 in 1977 and \$ 1.35 in 1980). It is assumed that other new projects will have no major outreach costs by 1980.

Items 11, 12, 13, 14: 1977 figures taken from project documents as submitted TAC/CGIAR.

Item 15: Very provisional and probably low initial estimates by TAC Mission.

Item 16: 1977 and 1980 figures taken from report of the TAC (Skilbeck) Mission.

Item 17: 1977 and 1980 figures calculated from cost estimates supplied in USAID submission to TAC.

Item 19: A number of suggestions for new research initiatives, generally without detailed cost estimates, is before TAC. These include socio-economic research; a tropical fruit centre in Asia; further studies in depth on food legumes; aquaculture; a tropical forest institute, also possibly in Asia; water use and management; new biological control of plant approaches to diseases; pesticide residue studies, etc. It is impossible at this stage to estimate which will be recommended to and accepted by CGIAR for funding between 1975 and 1977, nor thereafter, but it would be unrealistic to assume that none will. The estimates therefore allow for start-up and running expenses of one major new programme in the period 1975-1977, and an additional one for 1978 - 1980.

Item 20: 1973, actual. 1977 take from estimates of six existing institutes (\$ 1.75 million) plus new project reports. (\$ 5.0 million), plus \$ 1.5 million related to item 19. 1980 is an overall estimate for all new projects including anything under item 19, based on the relationship of core to capital costs which was 4:1 in 1973 and 5:1 in 1977. In 1980 it would be 5:2:1 on the assumption made; but could be lower depending on the degree of recapitalisation of existing centres; and what new items under 11-19 were being built between 1977 and 1980. Since capital expenditure fluctuate much more widely and irregularly over time than core or outreach programmes the 1980 estimate must really be regarded as a national or contingency item. However it does not seem unreasonable in relation to the 1973 figures, which can be regarded as much firmer.

GLOBAL ESTIMATE OF FINANCIAL SUPPORT REQUIRED
FOR INTERNATIONAL RESEARCH ACTIVITIES 1974 - 80

	Recurrent Costs: US \$ Million		
	1973	1977 (C)	1980 (C)
1(a) <u>Six Existing International Centres</u>			
1. CIAT	3.40	5.22	6.76
2. CIMMYT	4.93	5.79	7.10
3. CIP	1.08	2.48	3.04
4. ICRISAT	1.20	4.20	4.90
5. IITA	4.80	7.67	9.13
6. IRRI	2.66	4.52	5.60
1(a) <u>Sub-total Recurrent Costs Six Centres</u>	18.07	29.88	36.53
1(b) <u>Capital Requirements Six Centres</u>	5.64	2.00	3.00
Sub-total Recurrent & Capital (a+b)	23.71	31.88	39.53
1(c) <u>Outreach Programmes Six Centers</u>	4.28	8.12	11.00
Total Centre-related Costs (A+b+c)	27.99	40.00	50.53
Outreach as % "Core" Research	24%	27%	30%
II(a) <u>Other Programmes Approved or Under Scouting</u>			
7. TAC (Technical Advisory Committee)	.16	.22	.27
8. CARIS Project (Agr. Res.: Inf. Sys.)	.12	1.00	.30
9. ILCA (Int. Livestock Centre Africa)	-	3.23	6.30
10. ILRAD (Int. Lab. Res. Animal Disease)	-	3.20	3.90
11. WANDA (West African Rice Dev. Ass.)	-	.90	1.05
12. ICRISAT Linkage Programmes in Africa	-	1.00	1.22
13. Near East/N. Africa Res. Proposal	-	2.00	3.20
14. Latin America: Beef or Bean Network	-	.15	.30
15. INTSOY (Int. Soya Bean Res. Base)	-	1.00	1.22
16. Crop Genetic Resources Network	-	.48	.70
17. <u>Contingencies (other proposals not yet costed)</u>	-	2.00	4.00
II a) <u>Sub-total Recurrent Costs "Other Programmes"</u>	.28	15.18	22.46
II b) <u>Capital Requirements "Other Prog."</u>	-	4.00	3.50
Sub-total Recurrent & Capital (a+b)	.28	19.33	25.96
II c) <u>Outreach Programmes under II</u>	-	2.30	4.00
Total Costs "Other Prog." (a+b+c)	.28	21.48	29.96
III <u>Grand Total all Programmes (1 II)</u>			
a) <u>Recurrent Costs</u>	18.35	45.06	58.99
b) <u>Capital Costs</u>	5.64	6.00	6.50
Sub-total Recurrent + Capital Costs	23.99	51.06	65.49
c) <u>Outreach Programmes</u>	4.28	10.42	15.00
Grant Total all Costs (a+b+c)	28.27	61.48	80.49

NOTES ON ITEMS LISTED IN Appendix 1 (a)

The global estimate shows ALL estimated costs of supporting existing and possible new international research activities; whether these have partial funds "in sight" from members of the Consultative Group or not. Where an advance commitment has been made to provide some of the necessary funding (e.g. USAID, INTSOY, the three co-sponsors to TAC, or FAO to the genetic resources network) this is taken as a normal donor contribution to the project and has not been deducted or identified separately. "Earned income" totalling \$ 668,000 in 1977, \$ 920,000 in 1977, and \$ 1.14 million in 1980, has been deducted from institute core funding requirements.

Items a(a) - 1-6: Recurrent "Core" costs include "restricted and unrestricted", and are taken from the 1973 budget submissions of the institutes summarized in the CGIAR review reports. Inflationary allowances are as indicated in those reports. The same rates have been used for projecting inflationary increases between 1977 and 1980. These are CIAT 8%, CIMMYT 7%, ICRISAT 5%, IRRI 6%, IRRI 7-1/2%. (An assumption of a steady level of inflation may, however, be optimistic on current trends).

Item 1(b): Capital requirements taken from budget figures for 1973 and institute's projections for 1977. No figures are available for 1980 but the figure has been raised over 1977 to allow for some recapitalisation.

Item 1(c): "Outreach" taken from budget figures for 1973, and projections for 1977 where available. In 1973 these average 23 percent of core budgets overall. This has been revised to 27 percent for 1977 and 30% for 1980 to allow for increases in the outreach work of CIAT, CIP, and a beginning of ICRISAT's ratios of 35, 46, 30 percent outreach to core expenses.

Item II(c): Item 7: TAC increases based on 7% compound annual rate of cost inflation from 1973 expenses of around \$ 160,000.

Item II(a): Item 8: The CARIS "pilot" project already being supported by CGIAR is expected to complete by November 1973. On the basis of an independent evaluation a decision will then be made as to whether to recommend support for the global project or not. The estimate for 1977 shows partial costs of undertaking this project (estimated \$ 2-1/2 million over 3 years); 1980 costs would be for updating.

Item II(a): Items 9-18: All assume a 7% rate of cost inflation on recurrent costs, additional to any programme increases.

Item II (a): Items 9, 10, 11, 12, 13: 1977 figures taken from project documents as submitted to TAC/CGIAR.

Item II(a): Item 14: Very provisional and probably low initial estimates by TAC Mission.

Item II(a): Item 14: 1977 and 1980 figures calculated from cost estimates supplied in USAID submission to TAC.

Item II(a): Item 16: 1977 figures taken from FAO submission to TAC. 1980 figures allow for one additional regional genetic resources center, plus support to IITA's programme.

Outreach. It is assumed that CIMMYT, IRRI, and IITA will maintain their respective 1977

Item II(b): Item 18: A number of suggestions for new research initiatives, generally without detailed cost estimates, is before TAC. These include a tropical fruit centre in Asia; further studies in depth on food legumes; agriculture; a tropical forest institute, also possibly in Asia; water use and management, new approaches to biological control of plant diseases; etc. It is impossible at this stage to estimate which will be recommended to and accepted by CGIAR for funding between 1975 and 1977, nor thereafter, but it would be unrealistic to assume that none will. The estimates therefore allow for start-up and running expenses of one major new programme in the period 1975-1977, and an additional one for 1978-80.

Item II(b) : Capital Requirements - " Other Programmes" Proposals approved by TAC or under serious consideration, which would require capital expenditure during the period 1974-77 include ILCA, ILRAD, the research needs of the Near East/N. Africa ecological zone, INTSOY, and the Genetic Resources Proposal. Assuming that ILCA (\$ 3.84 million) ILRAD (\$ 3.37 million) INTSOY (\$ 30.000) and the Genetic Centres (\$ 310.000) were to be funded in full and that two-thirds of the needs of the Near East Center were to be covered then, the total capital required would be of the order of \$ 14.5 million. A pro-rata estimate has been made for 1977 of \$ 4 million. For the period 1977-80 no data are available; but assuming the balance of the funding of the Near East Center had to be completed, one more genetic resources centre established, and one new research center comparable to existing ones to be initiated an order of requirement of \$ 12 million could be envisaged. A pro-rated figure of \$ 3-1/2 million has been assumed for 1980.

Item II(c): "Outreach" - "Other Programmes" 1977 estimates taken from ILCA, ILRAD, INTSOY and genetic resources proposals. That for INTSOY (\$ 880.000) is the sum required from CGIAR over and above 'core' requirements for the resource base. 1980 estimates are taken from the same reports, plus an addition for the Near East Center. The INTSOY requirement would rise to \$ 1.25 million.

Report on the visit to Mexico to attend the meeting
of the Board of Trustees of the International Maize
and Wheat Research Centre (CIMMYT)
1977

By

Dr. M.S. Swaminathan, Director-General,
Indian Council of Agricultural Research.
.....

Introduction

The International Maize and Wheat Research Centre (CIMMYT) is now 11 years old in its present form. Its roots date back to 1944 when the Rockefeller Foundation started its collaborative programme in Mexico in agricultural research. It is this collaborative programme that led to the development of the famous Mexican dwarf wheats bred by Dr. N.E. Borlaug and his colleagues, the assembly of a world germ plasm of maize and the identification of the Toluca valley as an excellent "hot spot" location for screening potato varieties for resistance to late blight.

The Institute is now supported by the Consultative Group on International Agricultural Research, a consortium of donors sponsored by FAO, UNDP and World Bank. This consortium now provides about 80 million dollars annually for supporting international agricultural research.

The policies and budget of CIMMYT are decided by a Board of Trustees headed by Dr. Virgillio Barco, presently Ambassador of Columbia in the United States. The Programme Committee of the Board met on April 1 and 2 and the Full Board on April 4 and 5. I attended both the meetings in my capacity as a Member of both.

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2. Important results of CIMMYT's work during 1976.

(a) Wheat and Barley: Three new CIMMYT-INIA (Mexican Research Institute) were released by the Govt. of Mexico during 1976. These are Nicosari, Ravon (both with white grain) and Tesopaco (red grain). We have seeds of these varieties for testing in India.

There was a serious outbreak of yellow rust in the Y qui valley of Mexico this year. Partly, this epidemic was due ^{to} a very large area (nearly 70%) being grown with a single variety, Jupateco. Early planting by a few farmers to take advantage of the soil moisture created by the Hurricane, Liza, also contributed to the early build-up of rust inoculum. The Govt. of Mexico sprayed 100,000 hectares with a new fungicide, Indar, imported from Europe. But for this step, the damage to the crop would have been very severe. The Mexican Minister of Agriculture told me that as a result of the spraying, the loss in the total output of wheat may be about 20%. The precise result will be known only after the crop is harvested. Meanwhile, the Mexican Govt. is embarking upon a varietal diversification programme in order to minimise the genetic vulnerability of varieties to diseases.

Good progress has been made in improving the yield potential of durum wheat, Triticale and barley. Distant hybridization is being resorted to in order to widen the genetic base. Long spikes with 35 to 41 spikelets each having about 8 to 14 grains have been obtained in some crosses but such plants are invariably late.

(b) Maize : The programme is very well organised and can help to produce high-yielding and disease-resistant varieties, composites and hybrids of maize. Emphasis is on early maturity and disease resistance. Aspects of post-harvest technology such as extraction ^{of} maize germ oil are also receiving attention. We have considerable scope for extracting large quantities of maize oil in Bihar where rabi maize has become popular. This will add to the income of farmers, while augmenting the availability of vegetable oils.

In 1976, over 10,000 crosses were made between maize and Tripsacum. A rare hybrid between maize and Jowar (Sorghum) has been obtained. The hybrid is however sterile but has given seedlings on backcrossing the F₁ with maize.

Both the wheat and maize programmes are being re-organised on a regional basis. The Regional centre for South Asia in Maize will be located at Hyderabad in the farm given to ICNISAT. The Economics Group of CIMMYT works very closely with the scientific groups in wheat and maize on the constraints responsible for the gap between scientific advance and production advance.

3. Recommendations of the Programme Committee

The following recommendations of the Programme Committee were endorsed by the Trustees.

a. Research tailored to the needs of small farmers:

The Committee is of the view that the production technology

developed by CIMMYT is neutral to scale with reference to the size of farm holding. Therefore, all farmers - small and large - can benefit from the new varieties and production technology provided national governments support the technology with appropriate packages of services and public policies. Since CIMMYT is measuring its effectiveness by production advances, it can help through its social-economic research group to identify the action required on the part of national governments and by bilateral donors for ensuring that the economic benefits of new technology accrue to all sections of the farming community.

b. Breeding philosophy and methodology:

The current breeding methodology in wheat, maize, barley and Triticale is compatible with the need for identifying varieties with wide adaptation as well as specific adaptation to suit particular soil and growing conditions. Co-operative programs such as those now under way in Brazil would help to identify high yielding varieties of wheat suited for cultivation in acid soils characterised by aluminium toxicity. National Research institutes supported by trainees from CIMMYT can develop location-specific varieties from out of the segregating populations either sent out to them by CIMMYT or developed in the respective programs. Varieties characterised by wide adaptation help to purchase time and therefore are valuable to countries which need to raise food output speedily. They also render seed production

easy in the initial stages of building-up a good seed industry. However, the conditions under which varieties with wide adaptation should be grown need to be specified, as otherwise there may be added problems such as build-up of inoculum of pathogens and pests. For example, the optimum sowing date for the variety should be made known to farmers.

The outbreak of leaf rust in Mexico this year has several valuable lessons for both research and extension workers. The genetic vulnerability to diseases caused by the cultivation over large contiguous areas of the same variety is well known. The wisdom of the multiline approach advocated and promoted by CIMMYT has thus become obvious. In view of the advanced stage of multiline breeding in wheat both in CIMMYT as well as in several co-operating programs, it would be advisable to convene a small workshop of concerned scientists, administrators and seed producers, to review the current status of multiline breeding and to suggest an action program for introducing multilines in commercial cultivation particularly in countries where the genetic diversity in the currently cultivated high yielding varieties is narrow.

c) Research priorities:

The Program Committee endorses the current emphasis on research relating to stability of yield. While this work should go on with added vigour, the following areas of research also need attention.

i) Research relating to the improvement of productivity per hect

Recent gains in production in maize and wheat in different countries have come both out of increases in acreage and of yield. There is however little or no scope for further area expansion in many developing countries.

Hence, the pathway of improved production should henceforth be higher yield per hectare. In order to focus attention on the size of the untapped reservoir existing in co-operating countries CIMMYT could stimulate and participate in an analysis of constraints responsible for low yield in a random sample of situations.

ii) Raising the ceiling to yield:

At present, the highest yields obtained in experimental plots are of the order of 8 tons per hectare. Production physiologists have calculated that this ceiling could be raised to about 12 to 14 tons per hectare. CIMMYT, in co-operation with other appropriate institutions in developed and developing countries, should launch an aggressive multidisciplinary program of research for bringing about a further improvement in the yield potential of wheat and maize. A paper on this subject should be prepared for discussion at the next meeting of the Program Committee.

A leading production physiologist such as Dr. L. Evans of CSIRO may be commissioned to work with CIMMYT staff in the preparation of such a paper.

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d) Quarantine arrangements:

CIMMYT should take all the necessary quarantine precautions in its seed exchange program. The Program Committee is satisfied with the arrangements currently made. In its view, the quarantine arrangements now adopted are satisfactory and will serve the purpose. However, since this is an important area of concern to all scientists and national governments, the Program Committee recommends that the Director General may invite a leading expert in seed pathology to review the procedures adopted by CIMMYT and recommend any further steps that may be advisable.

e) Collaborative research with advanced institutions:

Effective collaborative research with advanced institutions in developing and developed countries should be initiated in areas designed to bring about further advances in the yielding capacity of wheat and of maize. Effective linkages with appropriate institutions on a long-term basis would enable CIMMYT to pay adequate attention to the long-term goal of further improving the yield potential of wheat and maize, while at the same time CIMMYT itself could concentrate on the immediate goals of achieving stability in yield and exploiting the untapped yield reservoir already existing in farmers' fields.

4. Strategy for the release of Multi-line varieties of wheat

Since India is advanced in the development of multi-lines of Kalyan Sonu and Sonalika, it was decided that CIMMYT should sponsor an India in February, 1978, just prior to the International Wheat Genetics

Symposium, an International Workshop on Multiline Breeding CIMMYT will send an official request to Govt. of India.

5. Inauguration of the Asian Maize Research centre at ICRISAT

CIMMYT desires that Minister for Agriculture and Irrigation should kindly inaugurate sometime in October, 1977 the Asian Maize Research Centre being established at ICRISAT in Hyderabad with the approval of the Govt. India. A Maize Production Workshop will be organised at that time jointly by ICAR and CIMMYT.

6. Programme of collaboration between ICAR and CIMMYT in Maize and Wheat research.

The details of the collaborative programme were finalised as per note appended. The Canadian International Development Agency (CIDA) is prepared to finance the expenditure connected with this work plan. Deptt. of Economic Affairs is being requested to endorse this request.

7. Contribution of Indian Scientists to the work of CIMMYT

It is a matter of pride that the following Indian scientists are playing a key role in the research programmes of CIMMYT.

- a) Wheat Dr. S. Rajaram, Dr. G. Verghese, Dr. M.H. Khali
- b) Maize: Dr. R.L. Raliwal, Dr. N.L. Dhevan, Dr. S. Vasal and Dr. Rande.
- c) Sorghum Dr. S.P. Singh
- d) Economics : Dr. Sidhu.

8. Budget for 1978

The Board approved the following budget for 1978

(a) Operating Budget	-	US \$	12,387,000
(b) Capital Budget	-		343,000
TOTAL			12,730,000

M. S. Swaminathan

(M.S. SWAMINATHAN)
DIRECTOR GENERAL

WORK PLAN BETWEEN INDIAN COUNCIL OF AGRICULTURAL
RESEARCH AND CIMMYT, MEXICO, FOR SCIENTIFIC AND
TECHNICAL COOPERATION FOR RESEARCH ON MAIZE AND
WHEAT DURING 1977 and 1978.

...

The ICAR has a Memorandum of Agreement with CIMMYT according to which joint work plans have to be developed describing more specifically the activities to be carried out under this cooperative programme and setting forth the contributions of each party. The following work plan has jointly been developed for the years 1977 and 1978.

MAIZE:

Development and improvement of new maize strains:

Early to very early maturing varieties are needed for areas (i) with 200% or more cropping intensity, (ii) where maize crop is harvested early to sow potato in September, (iii) in riverine areas which are flooded in mid-August, (iv) in areas where sowings are delayed due to late receipt of monsoon and (v) where monsoon tapers off in early September.

1. The early to very early maturing varieties besides high yield potential should also have:

(a) resistance to foliar diseases caused by H.turcicum; H.maydis; Sclerotinia rayssiae var. zeae, etc.

(b) tolerance to high salt content in the soil

(c) tolerance to soil moisture adversities.

2. Maize varieties under cultivation in India have rather limited variability. Most of the varieties in the collection at CIMMYT are from Central and South American origin and are rather too late for the Indian maize programme. It is, therefore, desirable as a first step, to augment the available genetic variability.

3. Most of the maize varieties under cultivation in the countries to the north of the Black Sea and the Caspian Sea (above 45°N) in Europe, Canada and USA would prove exceedingly useful. Evaluation and collection of more promising maize material from the research stations through personal visits would be desirable. Moreover, in these visits additional useful information on the nature of work in progress could also be gathered.

4. For this purpose, one senior staff member of ICAR and CIMMYT shall form a team. Visits should preferably be made during September-November 1977, when the material can be seen in the experimental fields.

5. The introduced material shall be judiciously mobilized with the maize varieties already collected from the Indo-Gangetic Plains.

6. The original collections as well as the derived populations shall be evaluated at suitable locations under the All-India Coordinated Maize Improvement project, after quarantine clearance.

7. Evaluation for foliar diseases, soil salinity, etc. shall be carried out in India and Mexico.

8. Sources of resistance to major foliar diseases to be used in the population improvement programmes shall be based on the tests carried out during

9. The material collected from temperate areas will be evaluated in the winter season where maize cultivation is becoming very popular in North Bihar, Karnataka, Andhra Pradesh, Tamil Nadu and Eastern Uttar Pradesh.

Training and Exchange of scientific staff for in depth study of national and international programmes:

1. Programmes in India:

Each of the major maize growing regions in the country has a research centre. Few additional research stations particularly in the Indo-Gangetic Plains have been planned during the Fifth Plan. Over 300 coordinated yield trials are conducted each year. With the changes in staff at various levels, there is a continuing need for training research staff of various disciplines.

Accordingly, necessary training facilities are being provided within the framework of ICAR for the Indian maize scientists for different disciplines. In addition, need has also been felt for the training of extension staff responsible for the conduct of maize on-farm trials. ICAR proposes to organize suitable training programmes and CIMMYT may provide teaching aids and equipment not available in India.

2. Mutual exchange of staff:

Both ICAR and CIMMYT agree that considerable benefit can be derived by the mutual exchange of staff. Besides exchange of information, the scientists can more effectively develop and select material of direct use in their own programmes. Thus, ICAR proposes 6-month visits of scientists to CIMMYT at other locations each year. In addition, a short visit of about 4 weeks by a team of maize workers comprising different disciplines/stations to CIMMYT, Mexico or any other places of direct relevance is also proposed.

3. Visits by CIMMYT scientists:

One or more of CIMMYT maize scientists may visit India for varied lengths of time each year. These visits will provide CIMMYT scientists with an opportunity to share experiences with Indian scientists. To meet part of the CIMMYT travel necessary budget provision has been made in the present programme.

4. Exchange of seed material:

Each year CIMMYT sends out a large volume of maize material by way of progenies and experimental varieties. Likewise India shall also contribute material to the CIMMYT's international programme. The proposed budget includes an item for seed shipment.

5. Funds for supply of urgently needed parts of equipment:

A small budget has been provided to meet foreign exchange needed for the purchase and shipment of small component or parts thereof of important equipment.

To sum up CIMMYT shall collaborate with ICAR in the following manner:-

1. Exchange of seed material:

- a) CIMMYT will regularly provide the current maize germplasm developed in their out-reach programmes. These materials will include the progenies developed in elite maize populations as well as experimental varieties.
- b) CIMMYT will also arrange to provide regularly the genetic stocks and elite breeding material available in other current maize improvement programmes particularly those related to the special objectives outlined above in this agreement.
- c) If felt necessary, CIMMYT will supply reasonable quantities of material as some of the promising commercial hybrids/composite varieties for trials.
- d) ICAR will supply seed material of one or more sets of progenies developed in the Indian programme for tests in CIMMYT's international programmes.
- e) ICAR will also supply a reasonable quantity of seed material of experimental varieties developed in its programme for evaluation at CIMMYT.
- d) Data on the relative performance of experimental material will be exchanged.

2. Exchange of maize research workers and participation in research meetings:

- a) CIMMYT shall arrange visits by its scientists upto 2 manmonths/year to see this work in India and exchange ideas.
- b) CIMMYT shall arrange for appropriate maize research and production staff nominated by ICAR to visit CIMMYT or national maize programme of any other country for specialised study.

3. Mutual laboratory and field evaluation service:

- a) CIMMYT and ICAR in their quality laboratories would conduct check samples for protein, tryptophan and other attributes for quality analysis standardization.
- b) ICAR shall arrange testing of CIMMYT progenies against borer and downy mildow(s) in India
- c) CIMMYT shall provide for some essential laboratory or field equipment not readily available in India.

WHEAT:

Development and improvement of new wheat, triticale and barley strains:

CIMMYT is concerned in the wheat section with the improvement of four crops viz., bread wheat, durum wheat, triticale and barley for food and feed. In these four crops CIMMYT and the ICAR will continue to exchange germplasm as in the past with some specific modifications. Within the general framework of germplasm development fall a number of specific projects which can be of value to both parties.

1. Development of material for foliar disease resistance:

In the past few years wheat production has expanded into areas in which wheat was not grown extensively earlier. Such areas as West Bengal, Assam and Orissa make up a large part of this region. This region is characterised by high humidity and relatively high temperatures with a short growing season. Under these conditions such foliar diseases as Helminthosporium and Alternaria as well as stem and leaf rust are highly favoured. There is a need, therefore to develop varieties more suited to this area with adequate resistance to the foregoing diseases. CIMMYT is receiving increasing requests for suitable material to grow in similar regions of other countries of the tropics and subtropics. Hence a mutuality of interest derives from the two needs.

It is proposed that ICAR-CIMMYT should develop a joint programme of research on these foliar diseases. Under the All-India Coordinated Wheat Improvement Project of the ICAR, there are centres at Kalyani, Malda (West Bengal), Jorhat (Assam), Pusa (Bihar) and Bhubaneswar (Orissa). These centres will screen the wheat material provided by the CIMMYT and the other centres of ICAR against the diseases listed earlier. CIMMYT will supply needed equipment for this work which is not available in India.

Populations from diverse sources would be screened for resistance. Resistance sources would be incorporated into desirable varietal backgrounds both in India and at CIMMYT. F₁ seed and other generations would be exchanged for parallel selection work. Material derived from selection would be made available both to ICAR and CIMMYT. For India, such material would provide protection to the wheat crop grown in North-Eastern India and for CIMMYT they would provide material for distribution in other countries of the humid tropics.

2. Development of Improved Durums:

Durum wheats are important to the economies of central and southern States of the country. Durums thus far have not been materially involved in the wheat revolution, although two dwarf durums were recently released. It is considered that real improvement in yields can be made in this crop. In general CIMMYT material are late in maturity for Indian conditions as indeed in several other countries. India possesses some of the earliest germplasm available worldwide. Therefore, utilization of the material of Indian and CIMMYT programmes will be mutually beneficial in combining earliness and greater adaptation and yield potentials.

In collaboration it is proposed that India supply its early maturing materials to CIMMYT to be incorporated in its germplasm for the benefit of other countries. It is envisaged that both parties would make crosses and exchange some F₁ seed for top and double crossing with each other's material. Successful selections made by either group would be made available to both.

3. Improvement in Bread Wheat:

India would undertake to supply to CIMMYT its promising new material entering coordinated trials. India would also supply specific promising material from any generations, thought by Indian scientists to be valuable to CIMMYT on the request of CIMMYT scientists after observing them in the field. CIMMYT would undertake to involve such material, at their discretion, in their crossing programmes and ensure testing of Indian material which prove resistant in Mexico in its international trials. Any such material would be identified as to their Indian origin but could be used by any cooperating country. CI

would continue to supply as many of its international nurseries as desired by India, consistent with its abilities to supply.

4. Improvement in Barley:

CIMMYT barley material is being developed primarily for food and feed. They are generally poorly adapted to Indian conditions, at this time being somewhat later in maturity than desired. The Indian programme is well established and could materially assist CIMMYT in supplying material with genes for such characters as earliness, dwarfness and aphid resistance. On CIMMYT's side, its access to germplasm worldwide would be of great assistance when placed in more appropriate backgrounds.

5. Improvement in Triticales:

Triticale work is being conducted at four centres in India and country-wide tests have been organised. Canada through funds provided by IDRC is assisting with research at one of the centres. Thus far, triticale appears best adapted in the northern part of the Gangetic Plain and in the Himalayas. Improvement in adaptation for more southern warmer regions is needed and further work is required in improving kernel characteristics. Indian can provide good selection ground for adaptation and can conduct some research on seed development. It is proposed that CIMMYT supply larger quantities of F₂ material for selection in India in line with the observation that better adapted varieties can be selected from earlier generations. Screening nurseries and yield trials from CIMMYT will continue to be supplied. India will undertake to supply material from the coordinated trials or specific material requested by CIMMYT.

6. Winter-spring Crosses:

CIMMYT is crossing winter x spring varieties in bread wheat, durum wheat and triticales. India is interested in the segregates of such crosses with the aim of developing spring habit varieties with greater drought resistance for the more southerly dry states and winter habit varieties for higher areas of the Himalayas. CIMMYT would hence supply to India F₁ seed of spring x winter crosses for crossing with Indian F₁'s and varieties. Selected F₂ populations will also be supplied for selection toward both winter and spring varieties. Promising advanced material from CIMMYT will also be supplied. Improved material selected in India will be made available to CIMMYT for the improvement of its germplasm base particularly for greater drought resistance. This will allow CIMMYT to provide better adapted material for rainfall areas.

Training and exchange of scientific staff for/in depth study of national and international programmes:

1. Programmes in India

Pathology:

For a number of years many of the varieties being evolved at Indian research centres have proven to be susceptible to one or more of the rusts at the time of release. Primarily this has been due to insufficient selection pressure being applied in the nurseries which in turn has derived from insufficient inoculum being available for early infection. A series of discussions were held in March 1975 on this problem and as a result of those discussions it was decided that large quantities of spores would be collected each year from research plots and farm yields in different parts of the country. These collections would be held until the next season by various methods and a mixture of

collections from different parts of the country would be supplied to each of the research centres for inoculation. It was further decided that a training programme should be arranged at IARI in New Delhi, in the first two weeks in February 1976, with Drs. E.E. Saari and R.W. Stubbs in attendance. This training programme was accordingly organised. Scientists from different centres in India as well as from Nepal and Afghanistan participated in this training programme. Each participant was provided with certain pieces of equipment was paid for by the Netherlands Government, with CIMMYT acting as the purchasing agent for the equipment and its entering India as a contribution of CIMMYT, courtesy of Government of Netherlands.

1. Other training programmes in India:

Each wheat growing area of India has one or more active wheat research centres. Additional centres are being established in the Fifth Plan to service areas not adequately represented. In addition there are numerous testing sites to grow the approximately 500 coordinated trials of wheat, triticale and barley. There is a continuing need for trained personnel.

India proposes to establish a wheat research training programme based on the multi-disciplinary team approach at its AICWIP centre with the possibility of extending this facility to friendly neighboring countries. Outstanding trainees would be sent to CIMMYT for further training.

ICAR - CIMMYT will hold training programmes as and when necessary like the Pathology training programme organised at the IARI in February, 1976.

3. Mutual exchange staff:

Both ICAR and CIMMYT agree that considerable benefit can be derived by the mutual exchange of staff. Besides exchange of information, the scientists can more effectively develop and select materials of direct use in their own programmes. Thus ICAR proposes that one senior scientist should be sent for three-month training to CIMMYT each year for selection of material. Six young research workers should be sent for a 6 month period.

4. Visits by CIMMYT scientists:

Each year one or more CIMMYT scientists visit India for varying lengths of time to discuss problems with Indian scientists and officials. This is a direct charge on CIMMYT's very restricted core funds. Hence an item has been included to cover a part of the CIMMYT expenses.

5. Exchange of seed material:

CIMMYT sends a large number of nurseries to India each year as well as occasional bulk shipments of seed grain. Budgeting has been made to cover a part of this cost.

6. Funds for supplies, chemicals and replacement parts for equipment:

In many cases expensive equipment is immobilized due to lack of parts available in India. An item has been budgeted under this heading.

To sum up CIMMYT shall collaborate with ICAR in the following manner:

1. CIMMYT undertake to supply germplasm developed in its bread and durum wheats, barley and triticales within its power to respond to Indian requests.
2. CIMMYT will endeavour to obtain from its other collaborating country programmes material requested by Indian scientists. Supply of such seeds, it is understood, would be consistent with policies of such other programmes.
3. ICAR will supply on a regular basis its promising new material for use in the CIMMYT programmes.
4. If material developed in India proves useful in another country, ICAR will consider CIMMYT's recommendation that India may supply more seeds of those strains to the country concerned.
5. CIMMYT will provide seeds of varieties having potential under Indian conditions. As above, supply would be immediate or in the crop from the next season.
6. In the development of varieties of wheat or triticales for use in the humid tropics where foliar diseases are of extreme importance, ICAR and CIMMYT will collaborate in such a program using research facilities of West Bengal, Assam and Orissa, with CIMMYT supplying certain equipment needs and both parties freely exchanging parental and elaborated breeding material for use both inside India and in other similar regions of the world.

Plant Quarantine:

All in-coming and out-going material will be subject to Indian Plant Quarantine Regulations. The material will be handled by the National Bureau of Plant Genetic Resources.

TEXT OF DR M.S. SWAMINATHAN'S SPEECH ON THE OCCASION
OF ACCEPTING THE BORLAUG AWARD 1978

Tuesday, 4 September 1979

Dr Borlaug, Dr Bharat Ram, Prof. Wittwer, Dr Pal,
Sri C. Subramaniam, Dr Ramiah, Mr Suryarau,
distinguished colleagues, ladies and gentlemen:

May I say, Dr Bharat Ram, how privileged I feel to be here to receive an award bearing the name of one whom I admire very greatly. I greatly appreciate this honour - to be the recipient of an award bearing the name of Dr Norman Borlaug. You referred to him as the "Schweitzer of Agriculture"; and in fact, this is just the impression we got in the very first year of his arrival in India. In 1963 March, I and several of my colleagues had the privilege of travelling with Dr Borlaug all over the wheat belt in India and even then although we did not know the promise that is to be opened up later by the wheat material he sent to India, it was clear that the man behind the wheat variety was an extraordinary man - a man full of humanism. We had then hoped that he will be chosen for the Nobel Peace Prize and we were happy later when the dream came true. I, therefore, want to thank you for giving me this privilege of being associated with an award bearing his name.

My second reason for being happy today is the fact that the Coromandel Lecture this year is being delivered by another very good friend - Professor Sylvan Wittwer and you will shortly be hearing him talk about

the 21st century. We are of course just today concerned with the drought which is going on ~~all~~ in our country. But unless there are some people who can dream about tomorrow, who have the vision to think for the morrow, there will be no future at all and, therefore, I am happy that Professor Wittwer will be delivering this year's Coromandel Lecture.

A third reason to be happy about is the fact that the company which has instituted these lectures, awards and numerous fellowships - the Coromandel Fertilisers - have not only set very high standards in fertiliser production --in fact it is one of those factories where the percentage efficiency is very high in terms of installed capacity and what they produce -- but also have been sponsoring a wide range of activities indicating their deep commitment to the agricultural development of this country as a whole. The Coromandel Lecture series itself is a good example. It is now looked upon as a feature - an annual feature - of great significance in terms of stimulating thought, in terms of laying foundation for new action and so on.

Finally, I always look forward to the Coromandel Lecture and other associated functions for another important reason - that you see in front of you, Srimati Uma Rao's beautiful flower arrangement. It is always a treat to come on the dais when she makes these arrangements and that is also becoming an integral part of the Coromandel Lecture and its functions..... for these reasons, I am happy to be here today.

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When I see Sri C. Subramaniam in front of me,

I am reminded of a medal, I think one of the early medals, I got in 1965 probably, when he was Minister for Agriculture. I was chosen for the Birbal Sahni Award of the Indian Botanical Society and he came all the way from Delhi to Chandigarh because the function was organised on the occasion of the Indian Science Congress - and he came and gave a speech and delivered the medal. I came home the next day when my younger daughter, who is also here in the audience ---- I showed her the medal and she said "what is this medal? Are you still a student?"!

It was a very profound remark and I said "I would like to be" and she said "Which College?". I said "Unfortunately, I have left the college, but I would like to be a student all my life" and whenever somebody gives a medal, I am reminded of the fact that one is obliged to continue in the pursuit of knowledge and learning. It is now 35 years, 1944, I joined the Agricultural College in Coimbatore as a student. These 35 years I have been intimately associated with plants, with agriculture, first in a more narrow way and gradually in a broader way.

But I think two things I have learnt among other things - first is from plants. I think those of you who have read Buddha's statement about plants -- once he said "Plant is the only living organism in the world which is capable of unilateral love". In fact the tree in the forest provides shade even to the axe-man who cuts it. And this unilateral love is the one which has been advocated in our own philosophy and Lord Krishna put it in Bhagvad Gita, but Swami Vivekananda put it very nicely and I would like to read it out for you, because this is one of the ideals which I think all of us in this country should keep, at least try to adhere if not wholly -- it is difficult to do it -- but at least partially.

And I quote Swami Vivekananda's statement -

....."in this world always take the position of the giver; give everything and look for no return; give love, give help, give service, give any little thing you can, but keep out barter".....

Plants, I think, do it ^{if} and/human beings can also learn a little bit of this spirit it will be a great deal.

The other lesson is from the farmers; because our farmers again are those who teach us some pride in our poverty. In rural India there is tremendous amount of pride. They may be poor, but the concept of pride and poverty is one which the Indian farmer teaches us, whether it is drought ^{or floods} I have seen in 1972 drought, some World Bank experts went to Rajasthan where the farmers in Barmer and so on, had no drinking water; but nevertheless, when they came back, they were so impressed with the hospitality of those people! And I think, this is what is keeping our country alive.

There is one more reason, Dr Bharat Ram, I thank you for the award. Many times, one would like to be associated with good causes, one does not have the means to do it. I recall, when I was very young in 1930 or 1931 there was a lot of preparation in my house and we did not know what was going on because I was only about 5 or 6 years old. In an average middle class South Indian family, in those days, boys in addition to girls, used to wear ear-rings, bangles and ^{gold} chains. And my mother, one evening, systematically started removing all of them. I asked her "what is it you are doing". She said "tomorrow a person is coming who is fond of taking away the jewellery"

And that was Mahatma Gandhi because in those days my father was associated with Gandhiji's temple-entry movement and other movements in South India. And he used to stay in our home. But she knew that if I had nothing on, then Gandhiji would have discovered that all ornaments had been removed! So only those which she wanted to donate, she had kept on the body!!

But later on, of course, it was explained to us that all these were taken for a good cause. And that again had left a deep impression on ~~our~~^{my} minds that whenever one can give something, one must give ~~away~~. Therefore, if I get ~~the~~ awards of this kind, I welcome the opportunity to be able to be of assistance to a useful organisation. I have, therefore, requested and Coromandel have been kind enough to agree to my request, that the cash amount associated with this award should be given to an organisation in Delhi which is working for one of the most deprived sections of our society namely, the children of migrant and construction labour; because I think, they receive the least attention.

And with this I would like to ~~end~~ conclude with a poem from Rabindranath Tagore about what children teach us. Although we have been paying lip-service to the International Year of the Child, speeches have been made, but very little action; and the future of the country lies in the attention we are prepared to pay to children because the children and youth constitute a genuine majority of this country. And, therefore, I would like to read this poem and with that I hope many of us can emulate children in this respect. The poem reads as follows:-

... Child, how happy you are sitting in the dust
Playing with a broken twig all the morning;
I smile at your play with that little bit of

broken twig
I am busy with my accounts adding up figures
by the hour

Perhaps you glance at me and think what a
stupid game to spoil your
morning with

Child, I have forgotten the art of being absorbed
in sticks and mudpiles;

I seek out costly playthings and gather lumps of
gold and silver

With whatever you find, you create glad games

I spend both my time and my strength over things
I can never obtain;

In my frail canoe I struggle to cross the
sea of desire;

And forget that I too am playing a game.

With this quotation ends.

I hope we can really see that the children of
this country at least will not have to go to bed hungry
in the 21st century about which Prof. Wittwer is going
to talk. I thank you.

VISITS TO THAILAND, KAMPUCHEA, VIETNAM, RUSSIA AND GERMANY
12-28 November 1987

I visited Bangkok from 12-15 November to attend the Ramon Magsaysay Awardees Assembly. From 16-21 November, Dr. Glenn Denning and I visited several places in Kampuchea and Vietnam to review the progress of our collaborative research and training programs and to finalize the details of the 3-year program to be undertaken from 1988 with the generous support of the Government of Australia. Highlights of the different discussions are given below.

I. BANGKOK, THAILAND (12-15 November)

IRRI was awarded the Ramon Magsaysay Award for International Understanding in 1969 in recognition of its "seven years of innovative, interdisciplinary team work by Asian and western scientists, unprecedented in scope, that is, achieving radical, rapid advances in rice culture."

I was awarded the RM Award for community leadership in 1971. I therefore participated in the Ramon Magsaysay Awardees Assembly held in Bangkok from 12-14 November, both as a representative of IRRI and in my personal capacity. The topics discussed included the environmental and socio-economic impact of modern high yielding varieties of rice and other crops. It was recommended that all agricultural research institutions should take into consideration issues relating to ecological sustainability, economic viability and equity while developing and transferring new technologies. The recent work of IRRI in sustainable rice farming was appreciated.

The Rockefeller Brothers Fund (RBF) announced at the meeting its decision to establish a Trust Fund of US\$2 million to support projects which can help to extend the impact of the work of RM Awardees. An Advisory Board consisting of Minister K.T. Li (Taiwan), Mr. Mochtar Lubis (Indonesia), Dr. Dioscoro Umali, Dr. Perla Makil, and Dr. M. S. Swaminathan (Chairman) was set up to recommend grants for suitable projects. The first grants will be made in December 1988. Invitations to Awardees to submit projects will be issued in January 1988.

Drs. F. A. Bernardo, D. W. Puckridge and I reviewed the progress of Thai-IRRI collaboration in rice research, particularly issues relating to the organization of core research in collaboration with a National Research System. Dr. Bernardo also gave information on his visits to Burma and Indonesia.

II. KAMPUCHEA (17-19 November)

Dr. Denning and I left by Ho Chi Minh by car, accompanied by Dr. Vo Tong Xuan and Rector Nguyen Van Hanh, for Mocbai on the morning of 17 November. At the Vietnam-Kampuchea border at Mocbai, we were met by Vice Minister Chea Song and Mr. Kong Thai Bunthan of the Kampuchean Ministry of Agriculture and Dr. Greg Wells of IRRI. We went by car from Mocbai to Phnom Penh. The persons met and places visited between 17-19 November are indicated below:

Hon. Hun Sen, President of the Council of Ministers and Prime Minister
Hon. Kong Som Ol, Vice President of the Council of Ministers and Vice President of the National Committee for Receiving Humanitarian Aid
Hon. Mr. Say Chhum, Minister for Agriculture and Vice President of the Council of Ministers
Mr. Chea Song, Vice Minister for Agriculture
Mr. Kong Thai Bunthan, Director, International Cooperation, Ministry of Agriculture
Mr. Ouk Sok, Head, Prey Phdau Research Station
Mr. Leng Sothat, Breeder, Prey Phdau Station
Mr. Johanne Rutten, Oxfam Scientist, Phdau Station
Mr. Rafael Arancillo, World Council of Churches, Srok Bati Agricultural Station, Tonle Bati
Mr. Svai Sambat, Farm Manager, Srok Bati Agricultural Station, Tonle Bati
Dr. Chhann Saphan, Rector, Institute of Agriculture, Cham Car Dong, Phnom Penh
Mr. A. K. Pandey, Charge d'Affaires, Embassy of India
Mr. Marcello Bevacqua, Special Representative, UNICEF
Mr. Krishna Desikan, World Food Program
Mr. Brett Ballard, American Friends Service
Mr. Perry Smith, Church World Service
Mr. Tom Vanderlinden, Cooperation Internationale pour le Developpement et la Solidarite Economique
Ms. Jennifer Ashton, Joint Australian NGOs
Mr. Jim Hart, Lutheran World Service
Mr. Jim Taylor, Mennonite Central Committee
Mr. Leng Sophal, Ministry of Agriculture
Miss Phan Vannaravy, Ministry of Agriculture
Mr. Kim An, Head of Political Affairs, Ministry of Foreign Affairs

Places visited:

Vietnam Border to Phnom Penh by car
Prey Phdau Station, Kompong Speu Province
Srok Bati Station, Tonle Bati, Takeo Province
Institute of Agriculture, Cham Car Daong and nearby areas

Drs. Prabhu Pingali and Sam Fujisaka joined Dr. Wells, Dr. Denning and me in several of the discussions and visits.

Major points arising from the discussions:

1. Hon. Say Chhum, Minister of Agriculture & Vice President of the Council of Ministers
 - a. Cooperation between Kampuchea and IRRI is growing and has developed rapidly since the visit to IRRI in 1985 by Vice Minister Chea Song and Mr. Bunthan.
 - b. IRRI's training programs are very useful. The 13 trainees currently in IRRI are gaining valuable experience. Additional training will be needed next year in rice production, soil fertility maintenance and cropping systems.
 - c. Kampuchea has experienced severe drought during 1987. Some parts have been affected by floods. The shortfall in production may exceed 200,000 tons and urgent food aid will be necessary next year.
 - d. Kampuchea's major crop is rice. A good rice research institute is therefore vital for building a national food security system.
 - e. The copublication program is deeply appreciated.
 - f. Dr. Wells is rendering valuable service. The survey undertaken by Drs. Pingali and Fujisaka will be valuable. This survey has highlighted the importance of research on soil fertility, water management, crop management and development of a statistical data base.
 - g. The following will be the agenda for cooperative efforts during 1988:
 - i. Training: A batch of 15 trainees including some women will be sent to IRRI. In addition, specialized training will be organized in a few areas like GEU, INSURF, and water management. The trainees who return from IRRI will help to organize training programs in Kampuchea, thereby generating a multiplier effect.
 - ii. National Rice Research Institute: A joint Kampuchea-IRRI Project Design Team will be set up for preparing a blueprint for a Kampuchea Rice Research and Development Institute (KARRDI). KARRDI will have adaptive research cum testing centers in the different agro-ecological regions of the country, utilizing wherever possible existing centers, including those run with the help of NGOs. It will concentrate in the initial stages on:
 - ... development of location-specific varieties adapted to the climate, soil, and pest conditions prevalent in the different agro-ecological regions

... organize farming systems research and testing, including crops, livestock and fish

... organize at the national level coordinated varietal testing, soil fertility monitoring and farming systems programs, and develop integrated nutrient supply and pest management procedures

... develop/adapt suitable farm implements and post-harvest technologies

... organize training programs for researchers and extension workers

... develop software for extension work.

- iii. Agro-ecological map: Utilizing LANDSAT data and ground truth information, Dr. Wells will help in preparing an agro-ecological map.
- iv. IRRI Team: An IRRI team consisting of an agronomist, breeder, and technology transfer specialist will be located in Kampuchea in the first half of 1988. The Government will make available appropriate housing and office facilities.
- v. Krom Samaki approach (solidarity groups) will be utilized for promoting integrated pest and nutrient management and scientific land and water management.
- vi. IRRI scientists will visit Kampuchea in accordance with requirements and develop collaborative research programs.
- vii. Agricultural stations being developed with assistance from non-governmental organizations at Prey Phdau (Oxfam), Tonle Bati (World Council of Churches) and at other locations will be linked in an appropriate manner in a national rice research, training, and development program, in order to optimize the benefits from the available infrastructure.
- viii. Germplasm: IRRI will send additional germplasm of rice, cowpea, green manure, and other crops.

2. Hon. Kong Som Ol, Vice President of the Council of Ministers

- a. Technology-Sharing Workshop (TSW): The Ministry of Agriculture of Kampuchea and IRRI will jointly organize in April 1988 a TSW to identify priority areas for research and training and to accelerate the transfer of the best available know-how to the field. Such a workshop could be held in conjunction with the general meeting of agricultural officers normally held in April after the announcement of the budget.

The first TSW could be structured in such a way that both specific topics and general problems are discussed. The specific topics to be discussed at the April 1988 TSW could include:

- o Soil fertility maintenance
 - o Water management
 - o Varietal choice
 - o Integrated pest management
- b. Kampuchea Rice Research and Development Institute (KARRDI): A Project Design Team should be set up immediately under the chairmanship of Vice Minister Chea Song. The report of Drs. Pingali and Fujisaka will be a valuable input in the preparation of the project proposal.
- c. Agro-ecological map: The preparation of this map should be completed soon, utilizing the available LANDSAT and ground truth information.
- d. Germlasm collection and conservation: IRRI has rendered an invaluable service in this field. A Kampuchea-IRRI joint collection work can be organized in 1988 in the southwestern Kampuchea, adjacent to the Mekong River.
- e. Office and housing for IRRI scientists: In view of the importance of collaboration with IRRI in the most vital sector of the Kampuchean food economy, suitable office, laboratory, and residential facilities will be provided to IRRI scientists. IRRI's assistance and the work of Dr. Wells are greatly appreciated.

3. Hon. Hun Sen, President of the Council of Ministers

The Hon. Prime Minister Hun Sen indicated the following priority tasks:

- a. Increase in rice production is not commensurate with the growth in population. The annual growth rate in population may be as much as 3 percent and this will call for a 9 percent growth rate in the agriculture sector. Unfortunately, agricultural growth is practically stagnant due to climatic, economic, and political factors.
- b. To increase production, a 3-pronged strategy should be developed with the help of IRRI:
- i. Increase the area under cultivation based on scientific land use planning criteria; for this purpose, complete the preparation of the agro-ecological map; divide the

land area into:

- o Intensification areas
- o Ecological restoration areas

Interpret the satellite imagery into descriptive terms for use in land use planning.

- ii. Increase productivity per crop, using techniques which can help to achieve on a sustainable basis yield increase at as low cost as possible; substitute to the extent possible farm grown biological inputs for imported chemical inputs; identify location-specific varieties.
 - iii. Increase the intensity of cropping through suitable multiple cropping sequences; only 10 percent of arable land is now under double cropping; identify suitable crops and varieties based on ecological and marketing considerations.
- c. Germplasm conservation is important. IRRI could supply seeds of floating and deep water varieties, particularly those collected from Kampong Chhnang province.
 - d. Training both at IRRI and in Kampuchea is vital.
 - e. Kampuchea Rice Research Institute (KARRDI): This institute needs to be established as soon as possible. Rice holds the key to food security in Kampuchea. The Kampuchea-IRRI Project Design Team should be set up quickly.

The Prime Minister expressed his gratitude to the Hon. Mr. Hayden, Foreign Minister of Australia, Ambassador John Holloway, and the Government of Australia for their generous and valuable assistance through IRRI for improving rice research and production in Kampuchea. The Prime Minister welcomed the news that assistance would be provided on a 3-year program basis and said that this will be particularly meaningful in planning effective research and training programs.

The Prime Minister also expressed his gratitude to Prime Minister Rajiv Gandhi, former Foreign Minister P.V. Narasimha Rao and Dr. G.V.K. Rao of India. He hoped that the Government of India will also extend help in the establishment and development of the Kampuchea Rice Research and Development Institute, along with the Government of Australia.

4. Hon. Mr. A.K. Pandey, Charge d'Affaires, Embassy of India

Mr. Pandey indicated the kind help currently being extended by the Government of India. He mentioned that the Indian Council of Agricultural Research has set aside funds for Kampuchea. Therefore, it will be appropriate for ICAR to join the Project Design Team for KARRDI.

State of the Art in Rice Research and Production in Kampuchea

IRRI scientists, with the help of Kampuchean scientists and scholars, have gathered useful information on the evolution of rice culture and improvement in Kampuchea. It will be useful to publish all this information in the form of a book, after getting the manuscript approved by the Government of Kampuchea. This will provide benchmark information, against which further progress can be measured. Drs. Denning and Wells can help to get such a book prepared with the help of Drs. Pingali, Fujisaka, and other IRRI scientists who have been involved in the Kampuchea-IRRI collaborative research and training program.

Follow-up ActionProject Design Team for KARRDI

On the basis of discussions held with Vice Minister Chea Song, the composition of the Project Design Team for preparing a blueprint and for identifying suitable headquarters location for the KARRDI was finalized, in accordance with the desire of Prime Minister Hun Sen that immediate action should be taken in this matter.

Composition of Project Design TeamKampuchea:

Hon. Chea Song, Vice Minister for Agriculture - Chairman
Dr. Chhann Saphan, Rector, Institute of Agriculture
Mr. Chan Tong Iv, Head, Agronomy Department
Mr. Leang Sam Hath, Head, Agricultural Mechanization Department
Mr. Thuch Meng Kheang, Head, Animal Husbandry Department
Mr. Lim Kean Hor, Head, Hydrology Department
Mr. Try Meng, Head, Agronomy Department
Mr. Leng Tek Seng, Director, Research Department
Mr. Ngak Chay Heng, Plant Protection Department
Mr. Kong Thai Bunthan, Director, International Cooperation
Department

IRRI:

Dr. G. S. Khush, Head, Plant Breeding Department
Dr. G. L. Denning, Associate Scientist, Training and Technology
Transfer Department and Project Leader, Indochina Program
Dr. D. W. Puckridge, Agronomist
Dr. Greg Wells, Consultant

Indian Council of Agricultural Research (ICAR):

A request will be made to the Government of India to nominate, if possible, Dr. A. M. Michael, Director, Indian Agricultural Research Institute, New Delhi, and the Director of the National Bureau of Soil Survey and Land Use Planning, Nagpur as Members of the Project Design Team.

The Project Design Team will complete its work by April 1988 so that its proposals could also be discussed with non-governmental organizations and other participants at the TSW scheduled at Phnom Penh in April 1988.

- Prof. Phan Van Dien, Head, Department of Plant Pathology
- Prof. Nguyen Van Luat, Director, Cao Long Delta Rice Research Institute
- Dr. S. Devalatta, Indian Rice Expert, Cao Long Delta Rice Research Institute
- Prof. Dr. Vu Tong Suan, Vice Rector, Can Tho University
- Prof. Nguyen Van Sinh, Rector, University of Agriculture and Forestry
- Associate Professor Dr. Le Trong Hien, Head, Research Center
- Mr. Le Minh Triet, Assistant Dean, Faculty of Agriculture
- Mr. Le Van Thung, Head, Department of Soils
- Mr. Phan Van Hien, Department of Agricultural Engineering
- Dr. K. V. Abhaya Ravappa, Coconut Agronomist

Institutions visited:

- Institute of Agricultural Technology of South Vietnam
- University of Agriculture and Forestry, Ho Chi Minh City

Hanoi

- Gen. Nguyen Ngoc Tru, Vice President of the Council of Ministers
- Gen. Nguyen Minh Thong, Vice Minister, Ministry of Agriculture and Food Industries
- Dr. Nguyen Van Hung, Vice Minister, Bureau of the Council of Ministers
- Prof. Da Anh, Director, Department of Agricultural Sciences and Technology (DAST)
- Prof. Dao The Tuan, Director, Vietnam Institute of Agricultural Science
- Prof. Vu Tuyen Hoang, Director, Food Crops Research Institute
- Prof. Nguyen Vy, Director, Soils and Fertilizers Institute
- Dr. Vu Van Trieu, Department of Scientific and Technical Cooperation with Foreign Countries, State Commission for Science and Technology

III. VIETNAM

Discussions were held at Ho Chi Minh City on 16 November and at Hanoi from 19-21 November. The participants in the different discussions and the places visited are as follows:

Ho Chi Minh City

Hon. Nguyen Cong Tan, Minister of Agriculture and Food Industries
Prof. Dr. Tran The Thong, Director, Institute of Agricultural Technology of South Vietnam (IATSV)
Prof. Pham Van Bien, Head, Department of Plant Pathology, IATSV
Prof. Nguyen Van Luat, Director, Cuu Long Delta Rice Research Institute
Dr. S. Devadatta, Indian Rice Expert, Cuu Long Delta Rice Research Institute
Prof. Dr. Vo Tong Xuan, Vice Rector, Cantho University
Prof. Nguyen Van Hanh, Rector, University of Agriculture and Forestry
Associate Professor Dr. Lu Trong Hien, Head, Research Office
Mr. Le Minh Triet, Assistant Dean, Faculty of Agronomy
Mr. Le Van Thuong, Head, Department of Soils
Mr. Phan Hun Hien, Department of Agricultural Engineering
Dr. K. V. Ahamed Bavappa, Coconut Agronomist

Institutions visited:

Institute of Agricultural Technology of South Vietnam
University of Agriculture and Forestry, Ho Chi Minh City

Hanoi

Hon. Nguyen Ngoc Triu, Vice President of the Council of Ministers
Hon. Nguyen Minh Thong, Vice Minister, Ministry of Agriculture and Food Industries
Dr. Nguyen Van Huong, Vice Minister, Bureau of the Council of Ministers
Prof. Do Anh, Director, Department of Agricultural Sciences and Technology (DAST)
Prof. Dao The Tuan, Director, Vietnam Institute of Agricultural Science
Prof. Vu Tuyen Hoang, Director, Food Crops Research Institute
Prof. Nguyen Vy, Director, Soils and Fertilizers Institute
Dr. Vu Van Trieu, Department of Scientific and Technical Cooperation with Foreign Countries, State Commission for Science and Technology

Dr. Nguyen Dien, Director General, Institute of Agricultural Engineering
Dr. Tran Quan, Vice-Director, Vietnam Institute of Agricultural Engineering
Dr. Nguyen Ngoc Thuy, Vice Director, Plant Protection Department
Mr. Dam Quoc Tru, Plant Protection Extension Officer, Plant Protection Department
Mr. Nguyen Ich Chuong, Vice Director, Department of International Cooperation
Mrs. Cu H.P. Tao, Protocol, Department of International Cooperation
Mrs. Hoang Tri Dung, Protocol, Department of International Cooperation

FAO

Mr. S. I. Zakhariev, Resident Representative, FAO
Dr. K. M. Badrudozza
Dr. Ad Spijkers, Programme Officer, FAO
Dr. C. P. Malhotra, Chief Technical Advisor
Dr. S. K. Suri, Instrumentation Specialist
Dr. Dutt, Sericulture Expert

Embassy of Australia

H.E. Mr. Ian Lincoln, Ambassador
Ms. Stephanie Shwabsky, First Secretary

Embassy of India

H.E. Mr. Johri, Ambassador
Mr. Atri, First Secretary

Institutions visited:

Plant Protection Department
Institute of Agricultural Engineering
Seed Center, INSA
Ministry of Agriculture and Food Industries
FAO Office
Embassies of Australia and India

IMPORTANT CONCLUSIONS

1. Collaboration with the University of Agriculture and Forestry, Ho Chi Minh City

An agreement was signed with the University for undertaking joint research and training programs (Annexure 1). Hon. Nguyen Cong Tan, Minister of Agriculture and Food Industries attended the signing ceremony.

2. Collaboration with Cuu Long Delta Rice Research Institute

During discussions with Dr. Nguyen Van Luat, Director of the Institute, and Dr. Devadatta, Indian Team Leader, it was agreed to undertake the following activities during 1988.

- a. Organize a joint germplasm collection expedition in the Mekong Delta to collect floating and deepwater rices and acid sulfate soil tolerant strains.
- b. Undertake crosses between floating and deepwater rices in order to develop non-shattering varieties. Grain shattering can reduce yield by as much as 40 percent in many floating and deep water varieties.
- c. Intensify research on green manure crops and blue green algae
- d. There is evidence that sheath blight is controlled when Sesbania rostrata is incorporated. These observations should be confirmed.

3. Collaboration with the Institute of Agricultural Technology of South Vietnam and the University of Cantho

During discussions with Prof. Dr. Tran The Thong and Vice Rector Vo Tong Xuan, it was agreed to strengthen further ongoing collaboration with these institutions.

4. Plant Protection Department, Hanoi

It was agreed to strengthen collaboration in the areas of integrated pest management and epidemiological and disease forecasting studies.

5. The Vietnam Institute of Agricultural Engineering (VIAE)

IRRI will send prototypes of hydrotiller, small harvester, manually operated pumps, and transplanting machines for testing in Vietnam. Information on warehouse dryers will be sent. An engineer from VIAE will come to IRRI in 1988 to work on fertilizer placement machines. Also, VIAE will send a woman engineer for training and to work in the Women in Rice Farming Systems Program. Before coming to IRRI, she will study rice straw mushroom production technology in Vietnam in order to improve the technology currently in use in the Pangasinan project in the Philippines. She will work with Mr. Bart Duff and Ms. Thelma Paris. VIAE will also supply prototypes of several new machines developed by it for testing at IRRI. Several of them are particularly suitable for use by women.

6. FAO Vietnam Office

Mr. S. I. Zakhariev, FAO Representative, kindly agreed to provide facilities for sending seeds, telexes, etc. through the FAO Office. IRRI will meet the expenses incurred by the FAO Office.

Dr. Badrudozza gave information on the reorganized set-up for agricultural research in Vietnam. An organizational chart showing the new structure is in Annexure 2.

7. Research priorities indicated by Hon. Nguyen Cong Tan, Minister of Agriculture and Food Industries

a. Cooperation between Vietnam and IRRI has been most meaningful and effective. Nearly 40 percent of the rice area in Vietnam is covered by IR varieties. IRRI strains have also paved the way for crop intensification due to their short duration. The training programs of IRRI have been very useful. One hundred thirty five Vietnamese scientists have been trained so far at IRRI and 26 more candidates will be going to IRRI during 1988. The 1987-88 Work Plan indicates a considerable strengthening of the partnership between IRRI and Vietnam. Thanks are due to the Government of Australia for generous help in expanding collaboration with IRRI in rice research and training.

b. There is need for strengthening collaboration in the following two areas during 1988 and beyond.

i. New directions in rice breeding: There is urgent need for intensive research to develop location-specific varieties adapted to different soil and climatic stresses and suitable for multiple cropping. Deep water rice improvement needs more attention. Modern genetic enhancement research should help to introduce new genes from distantly related material. IRRI can help Vietnam in giving a new thrust and orientation to the breeding of varieties which can make the best use of a given environment and help to reduce the cost of production without reducing yield. Vietnam can participate actively in the Problem Soils Research Cooperative being organized by IRRI.

ii. Increasing fertilizer use efficiency: The greatest challenge facing Vietnam agriculture is improving the efficiency of fertilizer use. Two million tons of fertilizer are being imported every year and even a 10 percent increase in the efficiency of use of nitrogenous fertilizers will be of immense benefit to the nation. Vietnam and IRRI should accord high priority to this goal under the International Soil Fertility and Sustainable Rice Farming (INSURF) Network. The Ministry will soon identify the lead center with which IRRI can collaborate in this area of research.

During subsequent discussions on this topic held in Hanoi, it was agreed that IRRI will arrange for the visit of Dr. Roland Buresh to study this problem and suggest how Vietnam, IRRI, and the International Fertilizer Development Center (IFDC) can initiate joint programs of research and demonstrations.

8. Suggestions of Hon. Nguyen Ngoc Triu, Vice President of the Council of Ministers

- a. Rice scenario in Vietnam: Rice production has been steadily increasing in Vietnam. The area under rice is about 5.7 million ha. The production increased from 10.30 million tons of unmilled rice in 1976 to 16.00 million tons in 1986. The total food grain production was 18.4 million tons in 1986. The target for food production during 1987 is 19.2 million tons but the achievement is likely to be only 18.0 million tons due to drought. During the last 4 years, the average annual gain has been 7.32 percent in yield and 7.71 percent in output. The present average yield is about 2.8 t/ha. This accomplishment has been facilitated by IRRI's cooperation in varietal improvement.
- b. Research goals: Higher yield coupled with greater stability of yield and more crops per year should be the major goals of research workers. The population of Vietnam is increasing and will reach 70 million by 1990 but the arable land is limited. A vertical growth in productivity and a higher intensity of cropping are therefore essential to achieve national food security. In the next phase of Vietnam-IRRI collaboration, highest priority should be accorded to the following three objectives:
 - i. Development of location-specific varieties, characterized by good yield potential and grain quality
 - ii. Development of integrated pest and nutrient management techniques and achieving cost reduction without yield reduction
 - iii. Farming systems improvement based on the twin principles of ecological sustainability and economic viability. Multiple cropping systems should be based on scientific principles which can help to maintain soil fertility and reduce pest outbreaks. Rice-maize rotation is becoming popular and rice-wheat, rice-potato, and other rotations need greater attention.

Hon. Nguyen Ngoc Triu expressed the gratitude of the Government of Vietnam to the Governments of Australia and India for supporting rice research and training. He hoped that the bonds of mutually beneficial collaboration between Vietnam and IRRI will continue to grow.

Collaboration with Soviet-Vietnam Center for the introduction, selection, and seed management of agricultural crops

This center established in 1983 has over 35,000 accessions of 68 species of agricultural crops. Though started as a plant introduction station, it now covers a wide range of breeding and seed production activities. The following Russian scientists are working in Hanoi and two more are working in Ho Chi Minh City:

Dr. Kozitxki, I.U.N. - Team Leader
Dr. Andrusenco, A.V. - Wheat Breeder
Dr. Lavrisenco, V.G. - Rice Breeder

In rice improvement, Russian germplasm is being used for breeding for cold tolerance, salinity resistance, blast resistance, and early maturity. Japonica lines from Japan and Korea are also being used. Collaboration between this Center and IRGC will be useful, since the Center has plans to expand its facilities and collection activities very considerably during the next few years. It will also be useful if Dr. Lavrisenco visits IRRI along with a senior Vietnamese scientist for exchange of ideas and for developing a collaborative program.

The center has recently released VK 1-91, the first semidwarf photosensitive variety to be released in Vietnam.

A long range plan for promoting sustainable development and for ecosystems and arid lands will welcome appropriate collaboration and conservation of rice germplasm support to IRGC.

Discussions in the field
Discussions were held to the rational utilization of...
importance of working...
sustainable rice farming...
Academy of Sciences.

IV. MOSCOW, USSR (22-25 November)1. Discussions with the State Committee on Science and Technology

The following attended:

Dr. A.M. Kaidala, Chief, USSR State Agro-Industrial Committee
Dr. S.A. Krivda, Chief, Section of Flora and Fauna
Ms. Ludmilla Bolshova, Senior Specialist
Prof. Yuri Yazan, Director, All-Union Institute for Nature
Conservation
Dr. A.A. Vinokurov, Chief of Division
Dr. I.P. Laoupashko, Chief of Division of Foreign Relations
Mr. A.A. Shelekhov, Councillor, Ministry of Foreign Relations
Dr. Leonid I. Petrenko, Deputy Chairman, Commission of the
USSR for UNEP
Dr. Vladimir M. Simonov, Head, Scientific Programmes Division
Dr. V.I. Karatayev
Dr. M.S. Swaminathan
Mr. Fadeev, Interpreter

Issues relating to conservation of plant genetic resources and biological diversity were discussed. The progress made since the days of Vavilov was reviewed. The contributions of IRRI in this field received high praise. I was informed that the Government of USSR is considering the organization of the following high level bodies for conserving biological diversity and for protecting the environment.

- o State Committee on Nature Conservation
- o All Union Society for Nature Conservation

A long range plan for the protection of the environment and for promoting sustainable development is under preparation. Mountain ecosystems and arid lands will receive special attention. USSR will welcome appropriate collaboration with IRRI in the collection and conservation of rice genetic resources. USSR is extending scientific support to IBPGR.

2. Discussions in the Soviet Academy of Sciences

Discussions were held with Academician Sokolev on matters relating to the rational utilization and protection of plants. Secretary General Gorbachev, in a speech delivered on 2 November 1987, has stressed the importance of working for ecological security. The work of IRRI on sustainable rice farming systems is of great interest to the Soviet Academy of Sciences.

3. Discussions in the Lenin All Union Academy of Agricultural Sciences

The All Union Academy of Agricultural Sciences is housed in a beautiful 16th century building. Dr. N.I. Vavilov was the first President of the Academy. I held detailed discussions with Academician A.A. Nikonov, President of the Academy, Academician Alyoshin, Director, All Union Rice Research Institute, Krasnador and senior officers of the Academy on matters relating to collaboration between the Academy and IRRI. Academician Nikonov made the following points:

USSR Party Leadership is giving a lead in science policy. A new agricultural research and development strategy is being prepared for the next 12 years. Ecological issues like genetic conservation and prevention of soil erosion will receive much greater attention.

Following the discussions, an agreement was signed by Academician Nikonov and me for the continued collaboration between the Academy and IRRI. The agreement was supplemented with a work plan on the basis of discussions with Academician Alyoshin (Annexures 3 and 4).

4. Discussions with H.E. Mr. Murakhovsky, Acting Prime Minister and First Deputy Prime Minister of Council of Ministers of USSR and Chairman of State Agro-industrial Committee

Since the Prime Minister of USSR was out of the country, the Acting Prime Minister, H.E. Mr. Murakhovsky kindly arranged a meeting to discuss problems relating to food security and international agricultural research. Mr. Poletaev, Head Government Commission on Environment, Mr. V.S. Prosin, Mr. Konkov, and Dr. Kaidalov also attended. Mr. Murakhovsky made the following points:

a. Secretary General Gorbachev, in his speech early in November 1987, placed emphasis on the following three issues:

- o Nuclear disarmament and peace
- o Food security
- o Ecological security

b. Vavilov's contributions have been great and it is sad that at the instance of Lysenko, Stalin had imprisoned Vavilov. The record has however been put right now.

c. Balance of nature has to be maintained. National and international agricultural research should accord the highest priority to ecological sustainability.

d. Irrigation is very important for food security. However, proper water management is important. Water use efficiency should receive much greater attention.

- e. More attention needs to be given to renewable forms of energy. In the Philippines, wind, solar, and geothermal energy could play a greater part in energy supply.
- f. There are good prospects for selecting plants for salt and cold tolerance. USSR will be happy to collaborate with IRRI in this area of research.
- g. Food problem is one of the major challenges facing scientists and political leaders. There is need and scope for greater international collaboration for making hunger a problem of the past.

I explained the major areas of research undertaken by IRRI.

5. Vavilov Centenary

On 24 November, the Soviet Academy of Science and the All Union Academy of Agricultural Sciences jointly organized a one-day symposium to commemorate the birth centenary of N.I. Vavilov. The meeting was held in conjunction with the Fifth Congress of the USSR Society of Geneticists and Breeders. Over 2,000 scientists from the USSR and from outside attended. I delivered a lecture on "Genetic Conservation: Microbes to Man" and presented, on behalf of CGIAR, copies of the book "Gene Banks and the World's Food" to Academician A.A. Nikonov, President of the Academy of Agricultural Sciences and Dr. V.I. Krivchenko, Director of the All Union Vavilov Research Institute of Plant Industry, Leningrad. This book by Plucknett et. al. is dedicated to Vavilov and this gesture was highly appreciated by Soviet scientists.

In his opening address, Academician Yu A. Ouchinnikov, Vice President of the USSR Academy of Sciences, announced that UNESCO has decided to commemorate the Vavilov birth centenary as a significant global scientific event. He paid tribute to Vavilov for first recognizing germplasm as a strategic resource for plant breeding.

Academician A.A. Nikonov, President, All Union Academy of Agricultural Sciences, gave a detailed account of Vavilov's life and achievements. He explained that due to Vavilov's initiation and vision, over 200,000 accessions of cultivated plants were collected from all over the world by 1940. He described Lysenko as a cunning, ambitious, and dishonest person. When Lysenko found that he will not be able to discredit Vavilov scientifically, he decided to eliminate him physically. Lysenkoism is a monstrous, anti-science, and anti-socialist doctrine. Because of Lysenko, classical genetics was banished in 1948 and geneticists were persecuted for nearly 20 years. Lysenko misused the name of Michurin for his own political ends.

Academician Nikonov concluded his speech by reading out a resolution praising Vavilov's contributions and condemning Lysenkoism.

Prof. G. Robbelen, President of EUCARPIA, read a message conveying the indebtedness of scientists everywhere to Vavilov. Prof. H. Stubbe and Dr. D. Metten indicated that at the Gene Bank in Gatersleben, German Democratic Republic, over 61,5000 accessions of crop plants have been assembled. These include:

Cereals - 28,856 accessions
Pulses - 13,850 accessions
Soybean - 1,050 accessions

Dr. V.I. Krivchenko, Director, All Union Vavilov Research Institute of Plant Industry, Leningrad, described the research activities of the Institute.

A 30-minute film on the life and work of Vavilov was shown at the end of the day. I have asked for a copy of this film for use by Dr. T.T. Chang in the Genetic Resources Training Program.

Vavilov's son was present at the ceremony. The whole program was moving and showed how political interference can cause incalculable harm to both science and scientists.

It stands to the great credit of current Soviet leadership both in politics and science that the record has been set right.

6. Discussions with Prof. Boris Vartapetian of the K.A. Timirazev
Institute of Plant Physiology, USSR Academy of Science

Details of the International Symposium on Plant Growth under conditions of oxygen stress proposed to be held at IRRI either in December 1988 or early in 1989 were discussed. The assistance of Prof. A. Kaddoura, Assistant Director General for Science in UNESCO, has been sought for arranging a visit by Prof. Vartapetian to IRRI to discuss the details of the technical program with Drs. B.S. Vergara, S. Akita, and others members of the Physiology Department.

V. BONN, GERMANY (26-28 November)1. Meeting in BMZ

The following attended:

Dr. T. Schurig
Dr. D. Bommer
Dr. de Haas
Dr. Klaus Lampe
Dr. Von Poschinger-Camphausen
Mr. Robert Grundler
Dr. M. S. Swaminathan

After a review of German-IRRI collaboration, the following areas were identified for action:

- a. Role of IRRI in countries with strong National Agricultural Research Systems: The Minister for Economic Cooperation of Germany wonders what role IRRI can play in China which has a strong NARS. I agreed to send information on IRRI's contributions in research, training, and in the development of the China National Rice Research Institute. I also agreed to send a copy of Minister He Kang's speech at the International Rice Research Conference held at Hangzhou in September 1987.
- b. Role of IRRI in East and Southern Africa: BMZ is interested in supporting IRRI's work in east and southern Africa with significant activities in Tanzania. I promised to get a project prepared with the help of Dr. K.G. Pillai and this could be sent to BMZ after review by Dr. Lampe.
- c. WARDA-IRRI collaboration: BMZ had kept a contract ready for signature (Annexure 5). It was decided that Dr. Lampe will discuss this with the Directors General of IITA and WARDA. Pending the finalization of the project, BMZ will transfer the 300,000 DM earmarked for this project to IRRI's core budget. MSS will send immediately a letter to Dr. Schurig requesting the transfer of DM 300,000 to IRRI's core budget. It will be explained in this letter that the transfer is necessary due to the delay in developing an agreed program of work. The WARDA-IRRI collaborative work will be started in 1988 on the basis of the agreement reached among Drs. Stifel, Terry, and Lampe.
- d. IRTP-Africa: BMZ will be willing to consider support for strengthening IRTP-Africa on the basis of the report of the IRRI mission. It is important that there is adequate scatter of testing sites in order to help in identifying location-specific varieties for the different agro-ecological regions.

- e. Sustainability issues: These are becoming increasingly important and this topic will be discussed at the CGIAR 1988 mid-year meeting in Berlin. Drs. Bommer and Schurig will like to receive the recommendations of the Expert Consultation on environment, socio-economic, and production impact of new technologies and of the meeting relating to the International Network on Soil Fertility and Sustainable Rice Farming.
- f. Future of CGIAR: CGIAR has probably reached its peak with regard to donor support. It may have to manage its programs with an overall outlay of about \$200 million. This will necessitate dropping some ongoing programs in order to undertake new initiatives. This issue will have to be reviewed by the 3rd CGIAR Review Committee.

2. Discussions with Dr. Volkmar Koehler, Parliamentary State Secretary, BMZ

Drs. Lampe, Bommer, Schurig, and I met Dr. Koehler for a discussion on international agricultural research. Dr. Koehler made the following points:

- a. Since 1972, Germany has spent 280 million DM on international agricultural research. 31.5 million DM has been provided for in the 1988 budget for support to IARCs and NARS.
- b. Germany has many universities and research institutions which can play an active role in international agricultural research.
- c. Preoccupation with Africa should not cloud the importance of Asia in our work on food security. Population growth coupled with the restricted availability of arable land may enhance problems of undernutrition in Asia in the nineties. Hence, every effort should be made to improve rice yields wherever there is scope to do so.
- d. Germany can help actively in biotechnology research. Areas where biotechnology applications will be helpful should be identified.

During the discussion, Dr. Koehler welcomed my suggestion for BMZ support to Kampuchea and Vietnam through IRRI. Many Members of the German Parliament are interested in helping the Indochina region. Experience gained with working with NGOs is not wholly satisfactory. Therefore, the help of institutions like IRRI will be very useful. I agreed to send a note on this subject indicating how we work with support from the Government of Australia and what kind of help from BMZ will be useful.

3. Press Conference organized by Arbeitsgruppe Tropische und Subtropische Agrarforschung (ATSAF) and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)

Dr. Lampe, Prof. Bommer, Dr. Hansjorg Elshorst of GTZ, and I briefed press representatives of the work of IRRI and other CGIAR institutions.

4. Visit to the Max-Planck Institute für Zuchungsforschung, Köln

The Institute carries out its research work in 4 major departments -- molecular basis of plant breeding, molecular genetics, biochemistry and plant breeding, and yield physiology. In addition, there is an independent research unit headed by Dr. Horst Lorz which deals with in vitro culture and genetic manipulation in cereals. I had detailed discussions with Dr. Lorz, who is participating in the RF-supported genetic engineering network in rice and with Drs. F. Salamini, Heinz Saedler, A. Stolarz, and F.J. de Bruijn.

The following points emerged during the discussions:

- a. Patent Laws and Privatization of Plant Breeding Research: These are resulting in an identity crisis among plant breeders working in institutions supported from public funds. Hereafter, Plant Breeding Institutions may have to have legal departments.
- b. Biosafety regulations: Germany has no well-defined biosafety regulations for recombinant DNA research. A meeting is being convened in December to discuss this.
- c. Genetic transformation: Elegant methods of DNA transfer are now becoming available and some interesting results have been obtained in Petunia. It may be useful to transfer transposons from maize or Antirrhinum into rice.
- d. Symbiotic nitrogen fixation (Leader: Prof. J. Schell): The major emphasis is on understanding the interaction between bacteria and plants. Studies on rhizobium-host interaction are in progress in alfalfa, soybean, and Sesbania rostrata. Work is being done on nitrogen fixing genes in S. rostrata, with particular reference to the nature of stem nodulation. An International Congress of Nitrogen Fixation will be held from 13 to 20 March 1988. Possible areas of collaboration with IRRI can be identified during that Congress.
- e. Work on rice: Drs. Horst Lorz, A. Stolarz, and Zabena Hartke are engaged in genetic engineering work in rice. Genotype IR39385 gives the best response with regard to yield of embryogenic callus. IR64 protoplast suspensions are homogenous. Somaclonal variation for resistance to Xanthomonas is being studied. Protoplast regeneration has not

been possible so far in indica rices. Different DNA transfer mechanisms are being studied.

Dr. Lorz will visit IRRI in January 1988 to attend the RF Genetic Engineering Research Cooperative meeting.

The Max Planck Institute for Züchtungsforschung will be interested in cooperating with IRRI in organizing joint training programs.

5. Meeting with H.E. Dr. Richard Von Weizsacker, President of the Federal Republic of Germany

The President made the following points:

- a. Conservation of biological diversity: This is an extremely important idea for common action. Youth should be involved in genetic conservation and opportunities should be provided to them to visit natural heritage sites.
- b. Kampuchea: IRRI is to be commended for its work in Kampuchea. IRRI's work should be strengthened in the Indochina region and in Burma.
- c. China: China's experience in improving agricultural production should be widely disseminated.
- d. Philippines: Germany will extend full support to the agrarian reform and rural development programs of the Government.
- e. Hunger: It is a matter for concern that in spite of spectacular scientific advances and huge grain surpluses, hunger is growing in the world. An in-depth discussion on why this is happening will be useful. The Berlin Academy of Sciences could organize a discussion on this topic prior to the CGIAR mid-year meeting.
- f. National Science Academy: In view of the federal nature of the German Constitution, organization of a National Science Academy may be difficult. However, this is an idea which is worthy of follow-up.

M. S. Swaminathan

(M. S. Swaminathan)

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- Annexure 2 - Organizational chart
- Annexure 3 - Agreement with Lenin All Union Academy of
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- Annexure 4 - Work plan with LAUAAS
- Annexure 5 - BMZ contract

MEMORANDUM OF AGREEMENT
Between
THE UNIVERSITY OF AGRICULTURE AND FORESTRY
And
THE INTERNATIONAL RICE RESEARCH INSTITUTE

This Memorandum of Agreement entered and executed this day of 16th November, 1987 at Ho Chi Minh city, SR. Vietnam by and between

The University of Agriculture and Forestry, Ho Chi Minh city, herein after referred to as UAF, with principal office in Ho Chi Minh city, Vietnam and represented by its Rector, Dr. Nguyen Van Hanh

and

The International Rice Research Institute, herein after referred to as IRRI, with principal office at College, Laguna, Philippines and represented in this Agreement by its Director General, Dr. M.S. Swaminathan.

WITNESSETH

Cognizant of the need to provide relevant high quality education to improve capacities for agricultural and rural development

Realizing the need to provide enlightened and progressive leadership in scientific and technological education necessary for the advancement of agricultural and rural development

Aware that the University of Agriculture and Forestry as a leading agricultural university in Vietnam, as a center for graduate studies in many disciplines and various fields of agriculture and as an Institution of Higher learning, has been mandated to provide high quality training and education in agriculture and related fields

Considering that the International Rice Research Institute as a world center for rice research, has also been mandated to assist in improving rice production in developing countries by producing appropriate technologies and to strengthen scientific personnel capabilities of institutions in developing countries working on rice.

Recognising that UAF and IRRI have a common dedicated interest in pursuing a manpower development program for the well being of Asians and the betterment of mankind.

NOW, THEREFORE, in consonance with the above premised, UAF and IRRI hereby agree and covenant on the following terms:

1. UAF and IRRI will collaborate on the academic training of scholars from Asian and other interested developing countries.
2. UAF and IRRI will collaborate on the development and implementation of specific projects.

ARTICLE I

This Memorandum of Agreement may be supplemented by work plans to be developed jointly, which describe more specifically the activities to be carried out under this cooperative program and which set forth the envisaged the contributions of each party. These work plans may originate with either party but will require the full approval of both parties for implimentation.

ARTICLE II

The parties to this Agreement may, by mutual consent, add, modify, amend or delete any words, phrases or articles in this Agreement.

ARTICLE III

This agreement shall take effect at the beginning of the UAF academic year comencing in June 1988, and with the endorsement of the ministry of Higher Education of SR. Vietnam, and shall remain in force for a period of 5 years unless sooner terminated, revoked or modified by mutual agreement between the parties. Likewise, this Agreement may be further renewed upon mutual agreement between the parties.

IN WITNESS WHEREOF, the parties hereunto have affixed their signatures.

University of Agriculture and Forestry (UAF)

International Rice Research Institute (IRRI)

by: *N. Hanh*

by: *M. S. Swaminathan*
16 November, 1987
M. S. SWAMINATHAN
Director General

NGUYEN VAN HANH
Rector

Signed in the presence of

Fun

1. IRRI will submit to UAF a list of candidates considered suitable for admission to the M. Sc. degree program of UAF. The candidates recommended for consideration will be in English. It is expected that most of these students will be from Vietnam.

2. After considering the applications, UAF will inform IRRI the names of those accepted for admission. IRRI will then issue their formal award letter of IRRI scholarships which provide for the students' travel to UAF and IRRI expenses, and the standard UAF fees for the duration of the degree program.

3. Each UAF-IRRI degree recipient, through the assistance of the UAF Dean of Graduate School and Departmental Chairman concerned shall start as early as the beginning of the second semester of his/her stay at

SUPPLEMENTARY WORKPLAN

Workplan for Collaboration in Graduate Degree Program between University of Agriculture and Forestry and IRRI

This memorandum of agreement sets forth the understanding between University of Agriculture and Forestry (UAF) located in Ho Chi Minh City, Vietnam, and the International Rice Research Institute (IRRI) located in College, Laguna, Philippines, on the establishment of linkage in high-level manpower development.

This Agreement is a supplement to the Memorandum of Agreement dated 16 November, 1987 which sets forth the general agreement between the parties and shall hereinafter be referred to as supplementary workplan.

ARTICLE I

TERMS AND CONDITIONS

1. IRRI will submit to UAF a list of candidates considered suitable for admission to the MS or PhD programs of UAF. The candidates recommended for consideration will be proficient in English. It is expected that most of these students will be from Vietnam.

2. After considering the applications, UAF will inform IRRI the names of those accepted for admission. IRRI will then issue them formal award letter of IRRI fellowships which provide for the students' travel to UAF and IRRI stipend, and all standard UAF fees for the duration of the degree program.

3. Each UAF-IRRI degree candidate, through the assistance of the UAF Dean of Graduate School and Department Chairman concerned shall form as early as the beginning of the second semester of his/her stay at

UAF, a Graduate Advisory Committee with a UAF Professor as Chairman of the Committee and at least one other UAF Professor and an IRRI Senior Scientist as members of the Committee. The formal appointment of an IRRI Senior Scientist on the Committee will be made after the student has completed his/her comprehensive examination, so the IRRI scientist's presence at UAF will not be required during the student's comprehensive examination. The IRRI scientist will serve as co-chairman of the student's advisory committee.

4. To facilitate the arrangement under Item No. 3, UAF will appoint the IRRI scientist as honorary member of its graduate faculty. For this purpose, IRRI will submit to UAF biodata of the concerned IRRI scientist.

5. Upon completion of the coursework at UAF, the degree candidate will come to IRRI conduct his/her thesis research, analyze data and prepare the manuscript in English. However, if the thesis topics deal with problems which are not common in the Philippines, such as gall midge, deepwater rice, certain problem soils, etc., the student may conduct the thesis research either partly or entirely in Vietnam.

6. The Chairman of the Committee at UAF of the PhD student will visit IRRI at least once to review the progress of his/her research. In special cases, it may be necessary to arrange such visits once a year for the duration of the thesis research at IRRI. These visits, including lodging and subsistence while at IRRI forms part of the IRRI fellowship award. However, there is no provision for such visit by the Chairman of the Graduate Advisory Committee of MS students.

7. The final examination of the students will be held at UAF. The conduct of the final examination must adhere to the Rules and Regulations of UAF and those of the Graduate School.

8. The UAF will grant the degree.

9. Publication of the student thesis research shall be done in concurrence with UAF and IRRI advisers and with their appropriate coauthorship. All such publications will be processed through IRRI editorial board.

10. UAF will bill IRRI directly for all university and related fees. The monthly stipend of the students will be sent directly to them by transferring the amount to the student's bank account in Vietnam.

11. The scholarship cost of each UAF-IRRI degree candidates including the visits of UAF professors to IRRI will be provided by IRRI.

12. Also, under this agreement, UAF may nominate to IRRI students from Vietnam who have their sources of funding to conduct their thesis research at IRRI. IRRI will try to accept them depending on the availability of accommodation and research facilities at IRRI and provided they meet the eligibility requirements for acceptance at IRRI.

13. The degree candidates will be subjected to all provisions of the Rules and Regulations of UAF and those of the Graduate School.

ARTICLE II

The parties to this supplementary workplan may, by mutual consent, add, modify, amend or delete any words, phrases, sentences, or articles in this workplan.

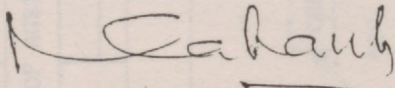
ARTICLE III

This supplementary workplan shall take effect at the beginning of academic year 1988-89 commencing in June 1988 and shall remain in force for a period of 5 years unless sooner terminated, revoked or modified by mutual agreement between the parties. Likewise, this supplementary workplan may be further renewed upon mutual agreement between the parties.

IN WITNESS THEREOF, the parties hereunto have affixed their signatures, this 16 day of November, 1987.

UNIVERSITY OF AGRICULTURE
& FORESTRY

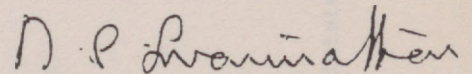
by:



NGUYEN VAN HANH
Rector

THE INTERNATIONAL RICE RESEARCH
INSTITUTE

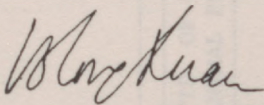
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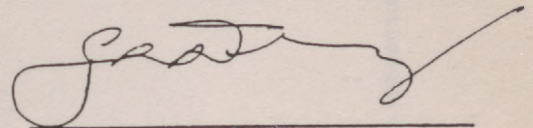


M.S. SWAMINATHAN
Director General

Nov 16, 1987

SIGNED IN THE PRESENCE OF:





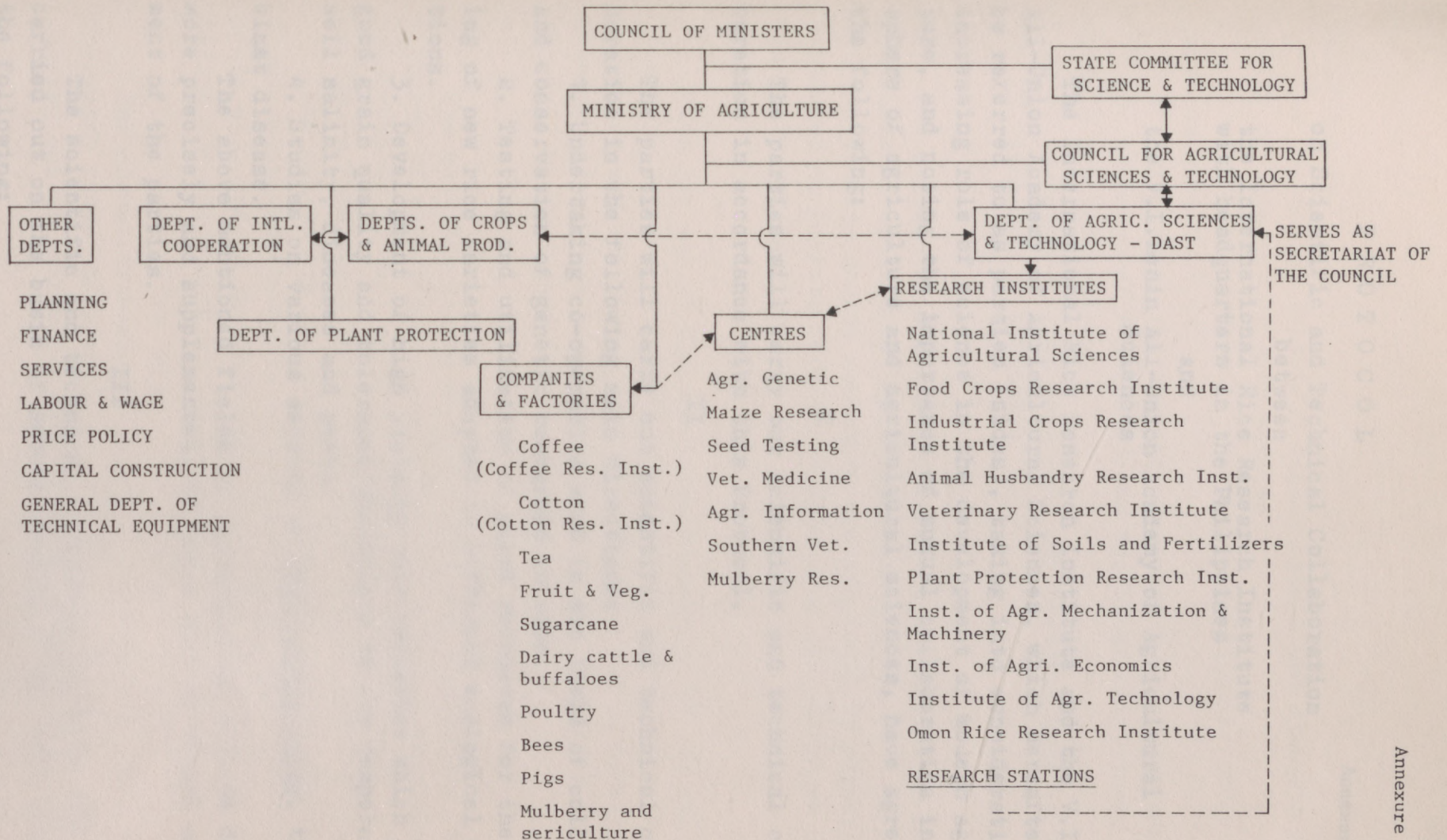


Fig. Organizational chart of the Ministry of Agriculture

PROTOCOL

Annexure 3

on Scientific and Technical Collaboration between

the International Rice Research Institute
with headquarters in the Philippines

and

the V.I.Lenin All-Union Academy of Agricultural
Sciences

The International Rice Research Institute and the V.I.Lenin All-Union Academy of Agricultural Sciences, which hereafter will be referred to as parties (sides), taking into consideration the increasing role of science in the development of modern agriculture, and noting the importance of mutual collaboration in the sphere of agriculture and agricultural sciences, have agreed to the following:

I

The parties will carry out scientific and technical collaboration in accordance with this Protocol.

II

The parties will carry out scientific and technical collaboration in the following main directions:

1. Undertaking co-operative work in the field of collection and conservation of genetic resources in rice.
2. Testing and utilization of plant resources for the breeding of new rice varieties adapted to different ecological conditions.
3. Development of high yielding rice varieties which possess good grain quality and tolerance/resistance to low temperatures, soil salinity, diseases and pests.
4. Studies on various aspects of Pyricularia oryza, the rice blast disease.

The above mentioned fields of collaboration will be defined more precisely and supplemented, if there will be mutual agreement of the parties.

III

The scientific and technical collaboration which will be carried out on the basis of annual working plans, will include the following:

1. Exchange visits of scientists and specialists for mutual sharing of experience, scientific and technical knowledge and

achievements.

2. Organizing lectures, consultations and symposia on topics of interest to both parties.
3. Conducting mutually coordinated scientific projects and research trials.
4. Exchange of the results of research and experiments.
5. Exchange of scientific and technical literature, materials and information.
6. Exchange of rice gene pool and breeding materials.
7. Exchange of trainees.

IV

The parties will promote conclusion of agreements and/or contracts on conducting joint researches.

Agreements and/or contracts are concluded by organizations empowered to perform foreign relationship operations on dates agreed by the parties.

V

With the aim of practical implementation of the collaboration, the representatives of both parties will meet as needed to review and coordinate research findings and to develop future working plans. Such meetings will be held alternately in USSR and IRRI headquarters in the Philippines.

VI

The exchange visits of scientists and specialists for exchange of experience, scientific and technical knowledge and achievements as well as the exchange of trainees will be based on the working plans jointly developed by the two parties.

The scientists and trainees will leave their countries only after having confirmation of the receiving party. The sending party will inform the receiving party not later than 30 days before the exact date of departure.

VII

The mutual exchange of scientific information and materials envisaged under the Article III, Item 5 of this Protocol will be carried out in accordance with laws (or rules) of the country

(or organization) which is giving the materials and information.

Each party in the bounds of its geographic area of responsibility has the right to use all the results of research and experimental work, which will be accomplished through this joint plan of scientific and technical collaboration.

In the international field of activity, each party will have the right to use commercially the results of the research and experimental work obtained by the other party according to the joint plan of the scientific and technical collaboration, only after the written consent of the other party.

The results of joint research may be published in accordance with mutual interests and mutual consent. Each party will be able to publish the results of the joint work separately, but only if there is written consent of the other party to do so. When publishing any scientific discoveries, each party will acknowledge the contribution of the other party, but at the same time will carry the whole responsibility for the conclusion and interpretation of the published materials. If mutually agreeable the parties may jointly publish research results.

VIII

The parties may on mutual agreement exchange delegations and organize arrangements not envisaged in this Protocol. Visits in this case are carried out at the expense of the interested party or on "host-pay-basis".

IX

The mutual exchange of scientists, trainees and delegations on the coordinated subjects will be based on the following funding arrangements:

- the sending party pays for the travel in both directions
- the receiving party pays all expenses during the stay in the country: the payment for the lodging, food and travel within the host country and also pocket money. If necessary, the host agency provides interpreters and ensures medical services in case of an accident or illness requiring emergency medical care or current treatment including expenses for meals,

medicines, stay in a hospital, medical examinations and treatments.

The expenses for the research and experimental work which will be undertaken during the procedure of collaboration will be paid by the party which fulfils the research. Specific working plans will be developed as and when needed.

Other matters of financial, commercial and judicial character, which may appear in connection with the scientific and technical collaboration, must become a subject of special agreements and contracts.

X

In solving the problems of cooperation outside the Protocol the parties will be guided by the general terms of the scientific, technical and economic collaboration between the USSR and international organizations.

XI

Working languages are English and Russian.

XII

This Protocol becomes valid on the day of its signature and will be in force for 3 years. It will automatically be extended for additional two year periods, if neither party provided the other a written notice of its desire to terminate it. In this case the Protocol will expire in six months after the date of such notice.

Done and signed in Moscow on November 25, 1987, in two copies in Russian and English languages, both texts being authentic.

M. S. Swaminathan

On behalf of
the International Rice
Research Institute

M. S. Swaminathan
Director General

A. A. Nikonov

On behalf of
the V.I. Lenin All-
Union Academy of Agri-
cultural Sciences

A. A. Nikonov
President

N	Subjects and Topics	Form of Accomplishment of Work	Forms of Co-operation and Terms of Transfer of the Results
1	2	3	4
1.	Exchange of samples of rice seeds and materials of their study.	Report on the results of studying the rice samples.	Exchange of 100-150 samples and relevant information.
2.	Development of the methodology for breeding salinity resistant varieties of rice.	Report on the results of studies following the methodology of breeding saline resistant varieties.	Gratis exchange of reports. Exchange of seeds of varieties-donors of resistance to salinity.
3.	Development of the methodology for breeding cold resistant varieties of rice.	Report on the results of studies following the methodology for breeding cold resistant varieties.	Gratis exchange of reports. Exchange of seeds of varieties-donors of cold resistance.
4.	Development of rapid-methods for technological and biological evaluation of rice grain.	Report on the results of studying express-methods for technological and biological evaluation of rice grain.	Gratis exchange of reports. Exchange of seed samples and their evaluation using the methods employed in each laboratory.
5.	Study of trisomic inheritance and linkage mapping in rice.	Report on the results of studying trisomic inheritance and linkage mapping in rice.	Exchange of seeds-markers of samples and of primary series of rice trisomics. Visits of scientists for 30 days to discuss programmes and carry out mutual research work. Gratis exchange of reports on the results.
6.	Tissue culture technique in the breeding process.	Report on the results of studies.	Gratis exchange of reports. Visits of scientists for 30 days.

7. Development of methods for breeding OMB rice lines.

Reports on the results of breeding OMB lines.

Gratis exchange of scientific materials and reports.

8. Exchanges in rice.

WORKING PLAN

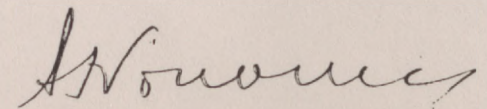
Report on the results of

Gratis exchange of reports.

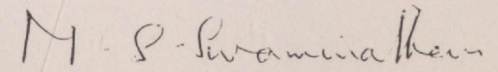
of Scientific and Technical Co-operation between
V.I.Lenin All-Union Academy of Agricultural Sciences
and the International Rice Research Institute (Philippines)
for 1958

1	2	3	4
7. Development of methods for breeding CMS rice lines.		Reports on the results of breeding CMS lines.	Gratis exchange of scientific materials and reports.
8. Heterosis in rice.		Report on the results of studies.	Gratis exchange of reports.
9. Exchange of trainees.		Training of IRRI specialists in USSR and Soviet specialists in IRRI.	Each side will send one trainee to the other side's Institute for 6 months (on an equivalent host-pay-basis). The topics and programmes of training will be agreed by correspondence by February 1, 1988.
10. Participation in symposia.		Exchange of information on the results reported in symposia.	Symposia are timed to coincide with the visits of scientists to the institutes.

All researches are fulfilled by the All-Union Rice Research Institute and the International Rice Research Institute (Philippines).



For the V.I. Lenin All-Union Academy of
Agricultural Sciences



For the International Rice
Research Institute

Federal Ministry for Economic Cooperation (BMZ), Bonn

and

International Rice Research Institute, Manila, Philippines

A G R E E M E N T

Mr. Thomas Schurig, Head of Section Agriculture, Rural Development and Agricultural Research, on behalf of the Federal Ministry on Economic Cooperation (further: BMZ) and Dr. M.S. Swaminathan, Director General of International Rice Research Institute (further: IRRI) agree upon the following restricted core programme:

- IRRI/WARDA Collaborative Research

- 1) irrigated rice development in the Sahel
- Breeding for cold tolerance
- 2) Breeding inland swamp
- 3) Water management studies

Research Plan

Research will be conducted as described in the IRRI proposal submitted to the BMZ. Any changes need to be notified in writing and confirmed.

Time Table

Research programme will be conducted within 1 (one) year after starting point which will be communicated to BMZ by IRRI. Extension of programme duration has to be approved by BMZ.

Funds

BMZ on behalf of the Government of the Federal Republic of Germany contributes to the agreed research programme an total amount up to 300.000,-- DM which is not eligible to exceed.

At the beginning of the fiscal year the amount will be proceeded in four quarterly disbursements.

Transferection will be made in Deutsche Mark.

Report Requirements

IRRI provides BMZ with following annual reports:

- report on research progress
- financial statement on expenses for the programme according IRRI's international monitoring principles.

Reports should be transmitted not later then March, 31 every year after ending of the previous fiscal year.

All reports should be written in English and proceeded in two issues.

After finalization of the programme IRRI provides an overall report about research work conducted and results achieved including an overall financial statement on funds spended.

Reports about particular activities and events within the agreed programme concerning work shops, training courses etc. should also be submitted to BMZ and ATSAF in two copies.

Publications

Equal publisher rights remain with IRRI and BMZ. All publications concerning the agreed programme or mention the programme should refer to BMZ as the donor country. A copy of these publication should be submitted for BMZ. In the case of charged publications it is agreed that buyers from developing countries are granted a 100 % discount. Cost recovery should be calculated to prices for buyers from developed countries.

Administration and Accounting

IRRI internal procedures agreed.

Capital Goods, vehicles, Research equipment

All goods purchased or built funded by the agreed programme shall become the property of IRRI upon arrival or construction. The afore mentioned goods shall be at the unrestricted disposal for the funded programme. In the case of damages, losses or repair responsibility for substitution or compensation remains with IRRI.

Controlling and Evaluation

The agreed programme is eligible for controlling and evaluation on determination by the Government of the Federal Republic of Germany or other authorized bodies and persons. Third parties need authorization by BMZ.

In the case of controlling or evaluation procedures IRRI will allow free access to its building, computer systems, accounting files and other items necessary and will actively support persons or bodies charged.

Commercial Utilization of Research Results

Commercial utilization needs to be approved by BMZ. The Copy Right for the whole research results achieved with the agreed programme remain with IRRI. In the case of commercialization of results IRRI will retain a fair share of the profit that could be realized probably.

Funds remaining and carrying over

In the case of remaining funds at the finalization of the agreed programme both parties will agree upon how they will be utilized.

Yearly contributions or parts of them are eligible for carrying over to the next fiscal year according IRRI principles.

National and International Rights and Settlement

This agreement does not intend or want to harm international rights and regulations nor national rights and regulations of the host country if so, these rights and regulations find application to this agreement.

In any case this agreement does not make provisions the application of international rights and regulations is determined.

**UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION**

**CONTRIBUTION OF BIOTECHNOLOGY TO SUSTAINABLE DEVELOPMENT
WITHIN THE FRAMEWORK OF THE UNITED NATIONS SYSTEM***

Prepared by

M. S. Swaminathan**

* The views expressed in this paper are those of the author and do not necessarily reflect the views of the Secretariat of UNIDO.

** Centre for Research on Sustainable Agricultural and Rural Development, Madras, India.

Preface

This paper has been prepared in response to a decision taken at a meeting of the United Nations ACC Task Force on Science and Technology for Development, held in New York from 6 to 8 February 1991. At that meeting it was agreed that the Task Force should concentrate over the next year on the area of the contribution of biotechnology to sustainable development and that a paper would be prepared to cover the national, regional and international (NGOs and UN) system/levels, with particular reference to socio-economic and legal implications, ethics, safety, the impact on employment, the international division of labour, etc. The paper was to be both analytical and forward-looking, with specific recommendations.

The Task Force agreed that UNIDO should take the lead in preparing the paper, with inputs from concerned organizations and agencies. The audience for this publication was to be the policy-making organs within the UN System that address biotechnology-related issues.

The present paper, which awaits consideration by the Task Force, has been written in a manner that is of interest to a wide audience. It is hoped that the recommendations contained in this paper will be acted upon by the international community.

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INTRODUCTION

Sustainable development demands the integration of the principles of ecological soundness and of equity with those of economic efficiency in the development of both technology and public policy. The broad group of technologies associated with modern biotechnology offer new opportunities for promoting a better quality of life for all, while living within the carrying capacity of supporting ecosystems, provided proper research priorities and strategies and public policies are followed.

The scientific principles and tools underpinning biotechnology are largely the outcome of research done in universities and public-funded institutions. On the other hand, the conversion of scientific discoveries into economically viable technologies is being done largely in the private sector in industrialized nations. The hard core of modern biotechnology is genetic engineering or recombinant DNA methodology, which enables the creation of novel genetic combinations. Such novel combinations need access to a wide range of genetic material, thereby resulting in a feed-back relationship between biotechnology and biodiversity.

These features of biotechnology have resulted in international debates and dialogues between industrialised and developing countries on matters relating to intellectual property rights and patenting procedures for living organisms on the one hand, and reward and recognition to the informal innovation systems of rural women and men, responsible for the preservation of a wide range of intra-specific genetic variability, on the other. The recent adoption of a revised UPOV convention for the protection of new varieties and the patenting of plant related biotechnological inventions, the statement of the Green Industry Biotechnology Platform and the acceptance of the concept of Farmers' Rights in FAO meetings are significant events in the ongoing debate on biotechnology and IPR. The establishment of an International Centre for Genetic Engineering and Biotechnology (ICGEB) by UNIDO is an important milestone in the history of biotechnology development for developing countries.

Biotechnological innovations offer scope for making substantial impacts on crop and animal husbandry, fisheries, forestry, biomass-based energy, bioremediation, health, industry, pollution control and a wide range of human activities having a bearing on sustainable development. No wonder many members of the UN family, as well as the World Bank and Regional Development Banks like the Asian, African and Inter-American Development Banks are playing a pivotal role in the development of biotechnological innovations and their widespread dissemination in developing countries. In addition, international scientific bodies like the International Council of Scientific Unions (ICSU) regional associations like the Commission of the European Communities and private industry are actively involved in various aspects of biotechnology research and development.

The human population is likely to double in about 35 years. More than 10 billion people will have to be fed, clothed and provided with jobs under conditions of shrinking land and water resources for agriculture, expanding biotic and abiotic stresses, increasing genetic erosion and rising cost of fossil fuel energy reserves. Compounding these social and economic problems is the possibility of alterations in climate, rise in sea levels and greater incidence of ultraviolet-B radiation, caused by both unsustainable life styles and the undesirable consequences of some of the current industrial and agricultural technologies.

It is in the above context that the Preparatory Committee for the United Nations Conference on Environment and Development (UNCED) concluded at its Third Session held in Geneva from 12 August to 4 September 1991, that the environmentally sound and safe application of biotechnology is essential for health care and food security, pollution control, higher efficiency of industrial development processes and biodegradation of industrial wastes. The Committee therefore urged the acceleration of current efforts on the development and application of biotechnologies, particularly in developing countries.

How can such a goal be achieved? Obviously this will call for institutional mechanisms which can ensure that public good and private profit are not mutually antagonistic. The UN principle of "one country one vote" helps to keep all points

of view in decision making. The UN principles are the ones which will promote harmony and understanding under conditions of diversity in needs, perceptions, socio-economic conditions, technological capability and biological wealth. How can the power of modern biotechnologies be used for promoting economic development without damage to the ecological health of our planet and for ensuring that the welfare of the poor is enriched and not eroded by technological progress?

During the last two decades, the institutional structure represented by the Consultative Group on International Agricultural Research (CGIAR), cosponsored by FAO, UNDP and IBRD, has proved to be an effective mechanism for reaching the resource poor farmers as well as for inspiring donor confidence. As a consequence, the annual budget of CGIAR comprising voluntary contributions by bilateral and multilateral donors and philanthropic foundations rose from about US\$ 10 million in 1971 to about US\$ 350 million in 1991.

Considering the far-reaching implications of biotechnology for human welfare and planet protection, it would be appropriate if a global coalition is formed through a Consultative Group for Biotechnology (CG-Biotech), which can bring together appropriate members of the UN system, bilateral and multilateral donors, foundations, private and public sector industries and governmental and non-governmental organisations. The CG-Biotech could help to mobilize the necessary financial, technical and institutional resources for ensuring that the benefits of "green" or environmentally benign biotechnologies reach the unreached.

The participants of the International Conference on "An agenda of science for environment and development into the 21st century" (ASCEND 21) sponsored by ICSU and held at Vienna from 25-29 November 1991, concluded that unprecedented crises are likely within the lifetime of half of the world's population, arising from such changes as:

- world population doubling to 10 billion in only 35 years;
- migration and urbanization, assuming dramatic proportions, with notable consequences on coastal zones;

- continuing rise of energy consumption exerting increasing pressures on the global ecosystem;
- climate change, sea-level rise and associated impacts on the biosphere;
- irreversible loss of a substantial part of the total number of living species;
- continued reduction and deterioration (including chemical pollution) of quality of the natural resource base including the exhaustion, degradation, salinization and loss of a major proportion of the world's soils;
- growing and widespread water scarcity.

Biotechnology can be a powerful ally in the development of avoidance and adaptation mechanisms which can prevent or mitigate the adverse impact of such crises.

Hence, no further time should be lost in the development of a suitable institutional framework, which can foster the growth of a global coalition committed to removing the technological component of the wall dividing prosperity and poverty. Innovative and dynamic institutional structures are essential for dealing with the human implications of a dynamic science. Suggestions are therefore given to convert the idea of a CG-Biotech into reality.

CHAPTER I

Sustainable Development and Biotechnology

1.1 Definition of terms

Sustainable development can be defined in several ways. The World Commission on Environment and Development (WCED) defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". This definition, in operational terms, creates problems in distinguishing sustainable development from sustainable growth. IUCN, UNEP and WWF in their strategy for sustainable living titled "Caring for the Earth" published in October 1991, have therefore preferred the following definition:

"Sustainable development is improving the quality of human life while living within the carrying capacity of supporting ecosystems".

A sustainable economy is the product of sustainable development. It maintains its natural resource base. It can continue to develop by adapting and through improvements in knowledge, organisation, technical efficiency, and wisdom. A "Sustainable Society" lives by the following nine principles:

- a. Respect and care for the community of life
- b. Improve the quality of human life
- c. Conserve the Earth's vitality and diversity
- d. Minimise the depletion of non-renewable resources
- e. Keep within the Earth's carrying capacity
- f. Change personal attitudes and practices
- g. Enable communities to care for their own environments
- h. Provide a national framework for integrating development and conservation
- i. Forge a global alliance

The document "Caring for the Earth" also provides indicators of sustainability and strategies for achieving sustainability. Among the indicators, the Human Development Index (HDI) of UNDP (1990), which includes the following three components, is regarded as an important one:

- a. Longevity
- b. Knowledge and
- c. Income

An ecologically sustainable society is one which

- a. Conserves ecological life support systems
- b. Conserves biodiversity
- c. Ensures that uses of renewable resources are sustainable
- d. Minimizes the depletion of non-renewable resources, and
- e. Keeps within the carrying capacity of supporting ecosystems.

Successful strategies for sustainable development have four components in common:

- a. Consultation and consensus building
- b. Information assembly and analysis
- c. Policy formulation
- d. Action planning and implementation

The inter-governmental negotiations currently in progress in connection with the 1992 UN Conference on Environment and Development (UNCED) relate in several aspects of the call of WCED "to transform this report into a UN Programme of Action on Sustainable Development". Conventions on climate, biological diversity and forests are under negotiation under the auspices of WMO, UNEP and FAO respectively. The following goal is also listed among the priority objectives of UNCED:

"Eradication of poverty and ensuring access by the poor to sustainable livelihoods and the requirements for human development"

What are the implications of biotechnology to these critical issues being grappled today in international fora? The literature on this subject is vast and quite opposing views are often expressed. Albert Sasson's book "Biotechnologies and Development" published by UNESCO in 1988 is a comprehensive and credible source of information on developments in biotechnology.

Henk Hobbelink's book titled "Biotechnology and the Future of World Agriculture" published in 1991 articulates very well the concerns of developing countries with reference to the potential adverse and positive impacts of biotechnology on global and national food security. The book "Agricultural Biotechnology: Opportunities for International Development" edited by Gabrielle J. Persley and published by C.A.B. International in 1990 gives a good overview of the role of international institutions in the development of biotechnology. The book "Social Consequences of Genetic Engineering" edited by David Weatherall and Julian Shellley (1989) is a good source of information on the interaction between science and society in the area of Biotechnology. Similarly, the book "New Technologies and the Future of Food and Nutrition" edited by Gerald Gaull and Ray Goldberg (1991) provides an excellent summary of the work done by private industry and of the problems arising from public perceptions on the safety of food arising from genetic engineering research. The book "Biotechnology in Agriculture: Reaching the Unreached" edited by M.S. Swaminathan and published by MacMillan India in 1991 is the most recent and comprehensive treatment on methods of imparting a pro-poor bias in the development and dissemination of biotechnological innovations.

The term biotechnology is currently being used to connote a wide variety of biological manipulations such as cell and tissue culture, embryo transplantation, transfer of DNA material across sexual barriers, vaccine production, bio-remediation, microbiological enrichment of cellulosic material, fermentation and various forms of biomass utilization. There are immediate opportunities for the

multiplication of superior clones of fruit and forest tree species, as well as plantation crops like cardamom and oil palm through tissue culture methods. Enhancing biomass production and its conversion into energy are important applications.

The hard core of biotechnology is recombinant DNA technology resulting in transgenic micro-organisms, plants and animals. The first transgenic plants expressing engineered foreign genes were produced in tobacco in 1983 by the use of Agrobacterium tumefaciens vectors. Since then, transgenic material has been produced in a wide range of plants, animals and micro-organisms. The Animal and Plant Health Inspection Service of the U.S. Department of Agriculture issued nearly 100 permits for testing genetically engineered material in the field between November 1987 and September 1990. The plants with new characters now under testing include maize, cotton, soybeans, potato, tomato, tobacco, alfalfa, cucumber, cantaloupe, squash, rice, walnut and poplar. We can expect even more rapid progress in the nineties as a result of the work of research networks like that supported in rice by the Rockefeller Foundation as well as due to the growing interest in the private sector for investing in biotechnology.

1.2 Biotechnology and Food Security

Since food is the first among the hierarchical needs of human beings, it may be appropriate to deal with food related issues first.

There has been considerable debate in recent years on the potential impact of new biotechnologies on agriculture. According to Ellen Messer and Peter Heywood ("Trying Technology: neither sure nor soon", Food Policy 15, pp. 336-345, 1990), the impact of biotechnology in overcoming hunger may have to await the next millennium. Since this view is not widely shared a few issues relating to research and extension in the field of biotechnology are dealt with at some length.

The significance of biotechnology for a better biofuture of the Third World can be illustrated by taking the example of Asian agriculture. Asia has over 50 per cent

of the global population, over 70 per cent of the world's farming families, but only 25 per cent of the world's arable land. At the beginning of the 21st century, the per capita land availability will be 0.1 ha. in China and 0.14 ha. in India. The average Asian population growth rate is 1.86 per cent.

The only pathway open to countries like China and India for feeding their growing human populations is continuous improvement in yield. This involves research which can further raise the yield ceiling. China has gone into the large scale exploitation of hybrids in rice for this purpose. The tools of biotechnology can help in raising the productivity of major crops through an increase in total dry matter production, which can then be partitioned in a way favourable to the economic part. Improved irrigation water management and the incorporation of genes for drought-tolerance in major crop plants are urgent necessities.

According to the Senior Advisory Group on Biotechnology (SAGB), a senior industrial forum for debating policy issues affecting biotechnology in the European Community, crop improvements under active development around the world using modern biotechnologies include disease and pest resistance, higher nutritional value and improved taste, longer storage life, tolerance of heat or cold, tolerance of salty soil, tolerance of wetness and aridity and reduction of post-harvest losses.

In animal husbandry also, the needs of developing nations, particularly in South and Southeast Asia, differ from those of the industrialised countries. Most of the productive animals in India, for example, are stall-fed. In India, this enables government to provide farm animals to landless labour families for increasing their household income. Such resource-poor animal-rearing families have to be assisted in running the enterprise as efficiently and economically as possible, by providing services in the areas of genetic improvement, health care, nutrition and marketing. Nutrition has to come from high-yielding fodder legumes and grasses grown in crop rotations and from enriched cellulosic material.

A market research report entitled "Biological Products for Aquaculture - A Worldwide Market Study on Vaccines, Therapeutics, Diagnostics, Hormones and Genetic Manipulations" published in 1990 by the Technology Management Group.

New Haven, USA, suggests that as aquaculture farms increase their production per unit space, effective disease and stress control will assume greater importance. The markets for vaccines, diagnostics, hormones and new feeds will increase. It is anticipated that by the year 2000, 25 per cent of world-wide seafood consumption is likely to be produced by aquaculture. Vaccines are seen as a growth area, since vaccines are still needed for many major diseases. In Scandinavia and parts of the USA, nearly all trout and salmon, produced by aquaculture, were vaccinated in 1989 as compared to 5 per cent in 1984.

Many companies are developing aquaculture therapeutics to meet the growing demand. It is estimated that over 50 per cent of the total global production of fish, shellfish and molluscs is lost to disease. Breeding programmes and genetic engineering have led to the production of new "boneless" breeds of trout that have a better feed conversion rate, and salmon which possess an antifreeze gene to enable them to survive in colder waters. Further research in fish breeding is expected to focus on growth acceleration, sex identification and determination, flesh quality, disease resistance, sea water adaptation, and the ability to utilize specific dietary components. Thus, biotechnological research is opening new windows of opportunity both in terrestrial and aquatic farming systems.

1.3 Industry

As regards industry, industrial processes based on modern biotechnology often consume less raw material, water and energy than traditional methods. They consume renewable organic raw materials rather than non-renewable resources. Typically, they do not rely on the use of hazardous compounds, and employ low temperatures and pressures. They produce biodegradable industrial waste, usually in smaller volumes compared with traditional methods. Micro-organisms able to decompose noxious and toxic substances in water, air, soil and solid waste provide safe and highly effective treatment of household and industrial waste. It is claimed that specially selected or adapted micro-organisms today can decompose more than fifty pollutants typically found in hazardous waste sites, rendering them

harmless and that biological methods of waste treatment and clean-up are often cheaper and more effective than physical and chemical alternatives. The clean-up of oil-contaminated soils using micro-organisms has proven particularly successful.

The following table, material for which has been taken from a SAGB document, illustrates certain products produced by modern biotechnology and their environmental pay-off.

<u>Product</u>	<u>Environmental pay-off</u>
Diagnostic agents:	
Modification of a natural micro-organism to produce glucose-6-phosphate dehydrogenase has improved production efficiency of this biochemical used for blood diagnosis.	One cubic metre of fermentation capacity now replaces 600 cubic metres of capacity, giving dramatic reductions in the consumption of raw materials, water and energy, and far smaller volumes of waste.
Antibiotics:	
An enzyme isolated from a modified micro-organism now makes the enzymatic conversion of penicillin G more efficient than chemical synthesis.	Elimination of most chemical outputs and chemical solvents; consumption of half the energy for the same output.
Detergents:	
Enzymes derived from modified micro-organisms are now used in more than 75 per cent of all "enzyme" detergents (already most	Energy savings of 30 per cent or more from lower temperatures; improved cleaning performance at lower temperatures, with preservation of colours and fabrics

of the world detergent market).

due to milder conditions.

Leather production:

Enzymes derived from modified micro-organisms are increasingly used for the removal of hair from animal hides and to treat chrome shavings in tannery waste streams.

Use of less lime and sodium sulphide to dissolve hair; elimination of large quantities of organic solvents in the production process; reduced biological demand for oxygen in waste water; re-use of chrome salts instead of dumping of chrome shavings.

Paper production:

Enzymes derived from modified micro-organisms now facilitate the separation of lignin from cellulose.

Reduction in the use of chlorine bleach in paper and pulp production by up to 35 per cent.

Plastics and polymers:

Modified micro-organisms now make practical the production of these materials from organic matter - e.g. bioplastic is already used in certain packaging applications.

Use of renewable raw materials; biodegradable product waste; no net addition of CO₂ when decomposed or incinerated.

According to a study of the UN Centre on Transnational Corporations, the use of recombinant DNA techniques has proved to be substantially more cost-effective in producing antibiotics than the conventional fermentation techniques. Alpha interferon could be produced in large quantities under US\$

1,000 per pound by recombinant DNA technology, whereas the conventional technology of purifying from human white blood cells would cost an astronomical US\$ 20 billion per pound. According to J.L. Glick, the use of recombinant DNA technology would yield a unit cost of US\$ 6.14 per pound with a concentration of 6 per cent antibiotics with fermentation beer, while the traditional method resulted in a unit cost of US\$ 13.32 per pound with a concentration of 1.2 per cent antibiotics. This sizeable cost reduction was made possible by the increased efficiency of the genetically engineered organism. In addition, a substantial cost saving was observed in the use of raw materials; savings of 50 per cent capital expenditure for equipment, building and storage, and utility bills for processes were achieved.

An immobilised cell system can be developed by genetically engineering a microbial strain. The use of an immobilised cell system rather than the conventional batch fermentation could bring about a considerable unit cost reduction in many cases. For example, for a two million pound plant producing a typical amino acid, the difference in the unit cost is quite substantial, US\$ 4.15 per pound for batch fermentation and US\$ 2.85 per pound for the immobilised cell system. In particular, the prices of two amino acids, methionine and lysine, which are sold in bulk as animal additives, dropped drastically from around US\$ 8 and US\$ 24 per pound prior to 1960 to around US\$ 1 and US\$ 2 respectively, 20-30 years later. At the same time, annual sales world-wide increased 70-fold for methionine from 1954 to 1980 and 450-fold for lysine from 1958 to 1980.

It is generally agreed that biotechnology holds its most immediate promise in the pharmaceutical industry. Recombinant DNA technology is expected to generate the large-scale manufacture of many drugs and vaccines at lower costs than conventional technology. The list of drugs to be produced by gene splicing techniques include human insulin, human growth hormone, human interferons, Hepatitis-B vaccine and penicillin G-acylase.

In the chemical industry, the application of biotechnology is becoming increasingly important. Since the beginning of this century, the chemical industry has been heavily dependent upon petroleum as a raw material. But because of the

rising cost and dwindling sources of petroleum, the chemical industry is turning more and more to the biotechnological possibilities of converting biomass and carbohydrates into chemicals. Thus, biotechnology plays a dual function of providing both the raw materials and a production process for the chemical industry.

In particular, most chemical processes are catalytic reactions requiring high temperatures and pressures. By contrast, biological synthesis utilizes nature's catalysts, or enzymes, which operate at much lower temperatures and pressures and require only moderate acidity. Traditionally, enzymes are extracted from plant or animal tissues. Today, however, microbial production of enzymes is proving to be far superior to the old methods. Yields are greater and more economical because of shorter fermentation time required, and growth media are inexpensive and the screening procedures for purity and efficiency simpler. Some of the market predictions are indicated in Tables 4, 5, 6 and 7.

The recent Gulf War and the Exxon oil tanker's spill in Alaska have underlined the importance of stepping up research on microbial remediation of such pollution. Bioremediation can also be used to desulfurize high-sulphur oil or reduce the viscosity of heavy oil. Bioremediation uses microorganisms to get rid of toxic chemicals. In cleaning up oil spills, mainly on land, it involves the stimulation of naturally occurring oil eating microbes with specifically formulated liquid fertilisers containing nitrogen and phosphorous. It is therefore vitally important for oil exporting and importing countries to develop capabilities in research and development and application of the technology. UNIDO has therefore initiated a Bioremediation and Oil Recovery (BIOROR) programme.

1.4 Biotechnology and Third World concerns

A reference needs to be made to a few of the major concerns of Third World scientists and political leaders relating to current global trends in the objectives and organisation of biotechnological research. First, the farm sector is a major export-earning enterprise for Third World countries. Therefore, there is genuine concern about the potential adverse impact of genetic engineering research

directed at finding substitutes for natural products. Some examples are: high fructose corn sweetener as a substitute for sugarcane sugar and substitutes for vanilla, cocoa and diosgenin extracted from **Dioscorea** species.

A second major concern relates to the safety aspects of genetic engineering research. Will tests be done in the Third World which are not permitted in the industrialized countries? Will "super weeds" arise from research aimed at the development of pesticide and herbicide resistant crop varieties? Will the ecological groundrules underpinning the field testing of transgenic material be the same everywhere?

Third, the nutritive quality and food safety issues relating to genetically engineered strains and growth promoting agents like bovine growth hormones need careful study, using criteria more relevant to conditions where under-nutrition and malnutrition are widespread. Will crop varieties with multiple resistance to pests contain toxins which will ultimately affect the health of the human beings or animals consuming their economic parts? What kinds of safety evaluation procedures are needed for food ingredients produced by microorganisms, single chemicals and simple chemical procedures and whole foods and other complex mixtures?

Fourthly, will the biotechnology revolution help resource-poor farmers increase productivity largely with the help of farm-grown inputs? How can we design mutually reinforcing packages of technology, services and public policies which can ensure that all rural people - rich or poor, land owners or landless labour families - can derive economic and social benefit from new biotechnologies? Is it possible to design a pro-small farmer and pro-poor biotechnology programme?

Fifthly, what will be the impact of the extension of intellectual property rights to individual genes and genotypes on the availability of such improved material to developing countries and resource-poor farm families? Also, will intellectual property rights be exclusively reserved for rewarding formal innovation, although the informal innovation system has played and is playing a key role in the

identification and conservation of plant and animal genetic resources? What are the rights of the farm families who have conserved and selected genetic diversity in contrast to the rights of the breeders who have used them to produce novel genetic combinations? How can the concept of genetic diversity as a common human heritage be promoted, if only a few can derive economic benefit from such diversity?

Sixthly, will priorities in biotechnology research be solely market-driven or will they also take into consideration the larger interests and the long-term well-being of humankind, whether rich or poor? In other words, will **orphans remain orphans** in the choice of research priorities and investment decisions? For example, rice is the staple of nearly half the human population most of whom live in Asia. Yet, the application of biotechnological know-how to solve some of the important problems in rice production would not have received the financial and scientific support they needed but for the decision of the Rockefeller Foundation to make a major long term investment in this area. Human diseases like leprosy also illustrate this point.

Finally, basic research underpinning the techniques of biotechnology has largely been carried out in universities and public-funded laboratories. However, the work on the conversion of scientific information into economically viable technologies has largely been undertaken in the private sector. This had led to the question whether the fruits of such research will be available only to those who can afford to pay adequately for them. For example, in agriculture, some experts have stated that while the "green revolution" technologies arising from research funded by philanthropic foundations like Rockefeller and Ford Foundations and by governments of developing and industrialized countries were available to all farmers who could derive benefit from them, the "gene revolution" technologies associated with biotechnological research may not likewise be available, since they owe their origin by and large to investments made by private companies and may be protected by patent rights. Where should the line be drawn between private profit and public good, particularly in a world characterized by glaring economic inequities?

The results of genetic engineering research in medicine, such as the production of insulin, interferon and different kinds of vaccines, are being disseminated by the pharmaceutical industry. Likewise, applications in animal health care and production can be expected to be spread by private industry. Similar may be the case of enzymes like renin used for making cheese. In the case of crop improvement, there is an on-going debate about methods of integrating the principles of equity with those of economic profitability. The basic dilemma arises from the fact that while developing nations often represent centres of biological diversity and have rich endowments of biological wealth, the capacity to convert biological diversity into biological productivity through science and technology resides predominantly in industrialized countries, where such conversion work is increasingly in the hands of private industry.

The above concerns can be met only by a proactive analysis of the potential beneficial and adverse impacts of biotechnological research, not only from the economic angle but also from the ecological, equity and ethical perspectives. Social scientists and ecologists should be involved in project design teams right from the beginning and should not just come at the end to make a post-mortem analysis. For biotechnology to lead to a better future for human-kind, we need a systems approach, keeping in mind Albert Einstein's exhortation that human well-being should be the ultimate objective of all scientific endeavour.

1.5 Socio-economic impact

There is considerable literature on the socio-economic aspects of biotechnology particularly in developing countries. As stressed at the outset, it is possible to impart a pro-poor bias to technology development and dissemination at the national and international level. For example, the green revolution technology in agriculture was scale neutral with regard to relevance to farmers cultivating different size of holdings. However they were not resource neutral since inputs are needed for output. Biotechnology affords an opportunity for integrating scale and resource neutrality in technology development. This unique opportunity should be fully capitalised by ICGEB in collaboration with IARCs (see Table 7 for a list of IARCs under the CGIAR network). The UN report on the overall socio-economic

perspective of the world economy for the year 2000 shows a widening gap in income and production performance. The ratio in the per capita income in countries like China and India in relation to countries in Europe was 1:2 towards the end of the last century. It has now reached the level of nearly 1:70. The socio-economic perspective reveals that such a trend may continue unless special efforts are taken to impart a pro-poor bias in technology sharing, training and trade. For example, agricultural biomass is the most important feedstock available to poor countries. In rural areas, biomass refineries can help to get value added products from such biomass. The European Community has promoted programmes in the area of LEBEN (Large European Bio Energy Network) and biorefineries. Such programmes are even more urgently needed in developing countries. The impact analysis of new technology innovations should include equity both in terms of gender and economic status.

The Economic Commission for Latin America and Caribbean has undertaken a detailed study on how social equity can be combined with the spread of new technologies.

Biotechnology can make a useful contribution for integrating brain and brawn in rural professions. For example, Kerala State in India is developing the district of Ernakulam as a Biotechnology District, for taking advantage of its rich educated human resource, particularly educated women, who often tend to be employed in unskilled jobs (see Swaminathan, 1991). The programme will include extensive tissue culture propagation of forest tree species, banana, cardamom and ornamental and medical plants, genetic improvement of cattle and poultry and the establishment of biomass refineries. The cause of educated unemployment is often not the lack of employment opportunities per se, but the paucity of employable skills in educated youth. The prevailing mismatch between the skills needed for the sustainable conversion of natural endowments into economic wealth could be ended through a carefully planned learning revolution.

Centres of training in biotechnology, based on the method of learning by doing can play an important role in ending this mismatch.

1.6 Poverty, employment and biotechnology

The two decades between the United Nations Conference on the Human Environment held at Stockholm in 1972 and the United Nations Conference on Environment and Development (UNCED) scheduled to be held at Rio de Janeiro in June 1992 has been a period of sustained, often path-breaking activity in the fields of development research and action. It has also been a period of unprecedented environmental sensitivity and of conscientious, often pioneering, research and action in respect of different aspects of the environment and its protection. Many lessons are to be drawn from the experience of these two decades; of them, an unshakable one surely is this: the goals of social and economic development are not conflicting goals; they must not be counterposed to one another, but must be integrated, in our thinking and practice, in a single process of sustainable development. The title "Environment and Development" for the Rio de Janeiro Conference conveys this message powerfully.

It is now clear to social science theory that the process of development is more than merely the growth of incomes. If the term development is to refer, as it must, to enhancing the opportunities for individuals to develop their full potential as human beings, then the goals of development are unattainable if the environment in which human beings live is polluted, degraded and destroyed.

Prime Minister Indira Gandhi and Barbara Ward articulated at the Stockholm Conference in 1972 the links between poverty and environmental quality. Since then, much has been spoken and written on this topic. While there is much to be learned from that discussion, there is no avoiding the fact that the creation of societies whose basis is the untrammelled exploitation of natural resources without regard for the social cost of such exploitation has vastly increased humankind's capacity to destroy the environment. No pre-industrial society or community can destroy vast forests as logging companies can. In addition, anthropogenic pressures on natural resources have also increased considerably, particularly in developing countries.

The crisis of the environment is one that affects not only the poor; it can, however, be said that the poor are the worst victims of the crisis. For those who still pursue traditional livelihoods and for whom the development process has not provided alternative forms of life and work, environmental degradation often entails the loss of occupations, of sources of fuel, and fodder and of access to hitherto common property resources. Working people, street dwellers, and other sections of the poor are the worst victims of industrial pollution and disaster; they are the worst affected by the pollution of water sources and by unhealthy living and work environments. Hence there is need to re-orient development strategies in a manner that the quality of human life is improved while living within the carrying capacity of supporting ecosystems.

In recent years, in different parts of the developing world, various schemes have been put into practice for the creation of employment - wage employment and self-employment - and other forms of income support among the urban and rural poor. There have been disaster-relief projects, some of them ad hoc, as well as sustained employment and other income-support schemes. The World Food Programme has supported many "Food for Work" and similar programmes designed to link productive work with household food security.

It is now recognised that schemes that guarantee manual employment for people who are unemployed can play an important role in providing disaster relief as well as providing regular sustenance through enhanced incomes for the poor. Such schemes have a crucial role to play in development policy. The International Commission on Peace and Food chaired by Dr. M.S. Swaminathan has therefore proposed a global initiative for an employment entitlements scheme that uses the labour and creativity of the poor to protect, sustain and enhance the quality of the environment. The International Commission on Peace and Food has recently proposed such a scheme for consideration at UNCED.

Such an international programme to ensure employment entitlements for sustainable development will require global vision and international commitment and cooperation. It will also - perhaps more importantly - have to be finely tuned to local circumstances, resources and opportunities. Such a scheme of

employment entitlements for sustainable development can, by way of illustration, be designed to

- arrest and reverse the damage to land and water resources and to forests;
- conserve and develop bio-diversity and balanced ecosystems;
- maintain watersheds and hydraulic cycles;
- prevent soil erosion and degradation;
- reduce the silt loads of tanks and rivers, and moderate floods and;
- recycle garbage and sewage for energy generation and composting;
- promote environmental hygiene;
- develop safe drinking water resources.

The need cannot be too strongly emphasised for detailed assessments of local resources, needs and opportunities. These must be made by concerned communities of participating people, and shelves of projects must be designed on the basis of such assessments.

Such a scheme to create employment entitlements for sustainable development also envisages the intensification of scientific research and extension activities in relevant areas. The areas include:

- soil erosion and degradation;
- restoring degraded lands;
- water conservation and management;
- monitoring climatic change and standardising avoidance and adaptation mechanisms;
- improved seed and feed production for aquaculture
- ocean capability and productivity studies;
- evaluating the impact of different levels of ultraviolet-B radiation on crop and farm animal productivity and on the vulnerability of ocean phytoplankton organisms; and
- standardising methods of saving endangered species and ecosystems.

To sum up, it would be appropriate to shift food security considerations solely from the global and national angles to the level of individual households and to link the livelihood security of rural and urban communities with the ecological security of nations. What role can biotechnology play in such a poverty elimination agenda? It is obvious that biotechnology can play an important role, through tissue culture and micro-propagation techniques, animal health care, propagation of elite forest tree species, aquaculture, and establishment of biomass refineries. The opportunities afforded by Recombinant-DNA techniques and microbiological transformation have much relevance to the development of new genetic strains of crops and microorganisms and to the establishment of biomass refineries designed to promote the preparation of value-added products from every part of the plant and animal biomass.

1.7 Biodiversity and biofuture

Our biological future depends on our ability to conserve and utilize the rich genetic diversity occurring in living organisms on our planet. The extent of ignorance on the number of species existing on earth came out clearly at a Conference on the Ecological Foundations of Sustainable Agriculture organized by the C.A.B. International at London in July 1990. Some experts felt that more than 50 million species may be occurring, particularly when we take into account invertebrates and microorganisms while less than two million have been described so far. This underlines the importance of training more biosystematists, particularly in relation to invertebrates and micro-organisms.

Unfortunately, there is much controversy on methods of saving and sharing the global biological wealth. Discussions on this topic are in progress in various international fora such as FAO and UNEP. The Keystone International Dialogue Series on Plant Genetic Resources has tried to throw light on methods of resolving opposing viewpoints. Terms such as "Farmers' Rights" and "Breeders' Rights" are freely used to indicate the importance of according recognition to the informal innovation system in conjunction with the rights already accorded to plant breeders in the 20 developed nations which have so far adhered to the rules of the International Union for the Protection of New Varieties of Plants (UPOV). The

ongoing discussions at the General Agreement on Tariffs and Trade (GATT) on Trade-related Intellectual Property Rights (TRIPs) are also important in the context of North-South relationships in germplasm conservation and exchange. Fourteen developing nations have proposed to the Negotiating group on TRIPs at the Uruguay Round of Multilateral Trade negotiations that plant or animal varieties or essentially biological processes for the production of plants or animals should not be subjected to patent protection.

Farmers and breeders are allies in the common task of advancing biological productivity. Therefore, their rights should be presented not as mutually antagonistic rights but as mutually reinforcing ones. Such a goal can be achieved if UPOV ultimately evolves into an International Union for the Protection of Breeders' and Farmers' Rights, with its membership including all countries - industrialized and developing.

The UPOV convention has now been revised. The concept of "dependence" which would ensure that a variety "essentially derived from another variety protected by Plant Breeders' Rights (PBR) cannot be used commercially without the permission of the breeder of the protected variety has been introduced". It should not be difficult to develop a methodology under the dependence clause which enables recognition and reward for informal innovation. The financial reward in this case will have to go to a special fund which can help to finance conservation and plant breeding activities in the country from which the key genetic material came. The participants of the Keystone Dialogue at their meeting held in Oslo in June 1991 have proposed a Global Initiative for the security and sustainable use of plant genetic resources. This North-South consensus programme will go a long way in resolving prevailing conflicts (Keystone Dialogue on PGR, 1991).

1.8 Potential adverse impact of biotechnology

There is growing volume of literature on the adverse impact of biotechnology on environment and health in addition to its potential adverse effects on equity related issues. The report of the Biotechnology Working Group based on reports

of public interest organisations in the USA has cataloged some of the potential problems in its report titled, "Biotechnologies Better Harvest".

The declaration of INUYAMA on human gene mapping and genetic screening and gene therapy brings out some of the ethical issues involved in genetic engineering research.

1.9 Bio-safety

There is considerable public apprehension on safety aspects particularly with reference to the release of organisms into the environment. The wholesomeness aspects also cause concern in the public mind as was evident in the case of bovine growth hormones. Efforts on the development of pest resistant strains creates apprehension in public mind on the possibilities of toxins doing harm to human health. On the other hand, there is considerable data on naturally occurring pesticides and their impact particularly in chronic doses on the health of the consumer. These are two issues which will have to be considered both nationally and internationally. Almost all countries which have active biotechnology programmes have mechanisms for safety regulations. The guidelines adopted by each country concerning safety have undergone changes during the last 20 years.

Nevertheless, there are still on going debates which would be evident from the following few illustrative examples of potentials and fears.

Researchers at the University of Minnesota, USA, have come up with the idea of producing genetically-engineered pigs specially designed for use as organ donors for human transplants. At present, there is a shortage of human donors for organ transplants and difficulties in finding compatible matches mean that many suitable patients do not receive transplants.

As farm animals are already bred in large numbers for food, the moral questions associated with using them as organ donors might not be a problem. The most suitable animal, because of its size and availability, would be the pig.

On the other hand, the US Department of Agriculture was being challenged by the Environmental Defence Fund (EDF) and several other groups to reject an application for a field test of a genetically engineered tobacco mosaic virus (TMV). The application from Biosource Genetics Corp. concerns trichosanthin, an active component of the Chinese medicinal plant Trichosanthes kirilowii. This drug has been shown to have abortifacient properties, inhibits tumour growth and the immune response, and has recently been shown to act selectively against human immuno-deficiency virus-infected cells. The equivalent gene for trichosanthin has been isolated from cucumber and inserted into a TMV vector with the aim of producing the drug in plants. Human haemoglobin and rice amylase were also to be tested. The test uses Biosource's Geneware technique which inserts genes into the cell cytoplasm rather than in the nucleus.

The EDF is a pressure group which has previously criticized some biotechnology field tests. It fears that the trichosanthin gene could be transferred accidentally into tomato plants (which are susceptible to TMV) and that this might result in exposure of humans to toxic levels of the drug.

Biosource Genetics Corp disagrees that there is any cause for concern, and claims that the EDF does not understand the biology of TMV adequately.

The US President's Council on Competitiveness argues that 'unnecessary burdens' must be removed to allow the USA to stay ahead in biotechnology, according to its 'Report on National Biotechnology Policy'. The administration should oppose any efforts to create new or modify existing regulatory structures for biotechnology through legislation, it says. The report argues that the risks of bioengineered organisms should not be exaggerated, stating "products developed through biotechnology do not per se pose risks to human health and the environment". The principle of risk-based rather than 'process based' assessment is championed. The Biotechnology Working Group intends to find ways of promoting inter-agency coordination and to address problems with state and local laws (which it says include NIMBY (not in my back yard legislation)). It highlights the current uncertainty over whether a tomato genetically engineered for pest

resistance would be evaluated by the US Department of Agriculture, Environmental Protection Agency or the Food and Drug Administration.

UNIDO has prepared a voluntary code of conduct for the release of organisms into the environment for being considered by the Informal UNIDO/UNEP/WHO/FAO Working Group on Biosafety. FAO has also been developing a code of conduct. National Governments have their own code of conduct. Some countries like Germany have serious reservations while others like Japan do not seem to share their view. For example, the Environmental White Paper called "The 1991 Quality of Environment in Japan" which represents the official view of the Japanese government, affirms that there have not been any particular environmental problems through the development and utilisation of biotechnology including recombinant DNA technology. This report was drafted by the Environment Agency, approved by the Japanese Cabinet and reported to the Diet as the unified view of the Japanese government. The voluntary code of conduct prepared by UNIDO under the auspices of the UNIDO/UNEP/FAO Working Group basically attempts to lay down the minimum commonly accepted principles in regard to the subject. It draws on existing directives and regulations and does not intend to develop new concepts. It stipulates general principles, the obligations of governments and the obligations of the proposer and the researcher. It has been framed in such a way that more specific guidelines could be built up on it for specific products or applications. Cooperation of the ICGEB, the OECD and several experts was also enlisted for the preparation of the code. The Preparatory Committee of the Member States of the ICGEB considered the draft of the code and expressed the view that it provided a good basis for international cooperation and also contained the essential elements which could be adopted in national biosafety regulations.

1.10 Proprietary and patent rights

The sphere of plant genetic resources collection, conservation, and use cannot be discussed without considering the issues of intellectual property rights, plant germplasm ownership, and the control of plant germplasm accessions in

gene banks. These issues have been the focus of substantial debate and publication in numerous international fora for nearly two decades.

Due to the very nature of the biotechnological entities, the issues of patenting in this field are still a matter of intense debate and many developing countries have yet to decide which direction to follow. Court decisions have shown that there still are different interpretations on the scope and enforcement of patent protection in the field of biotechnology.

One basic issue is whether the patent system for inventions is suitable of protecting proprietary rights related to living material. The United States Supreme Court affirmed the patentability of micro-organisms in 1980. In other developed countries there has been a trend in this direction, although the matter is still under debate at the national level as well as in multilateral negotiations, eg. the Uruguay Round in GATT.

Other forms of protection, applicable to plants and plant biotechnological innovation exists: the industrial patent and the plant breeders' right (PBR). This is a right granted by Government to plant breeders to exclude others temporarily from producing and selling propagating material of a protected plant variety. As mentioned earlier, possible developments in PBR laws are also regarded as a way of granting increased protection in genetic material and processes as sought by developed countries while allowing a less restrictive environment for the utilizer, as compared to the one derived from the current patent laws.

The practices and trends in technology transfer in the field of biotechnology have followed a pattern, which is intrinsically related to the genesis of biotechnology development, the market value of biotechnology entities, the costs of R&D activities, the intellectual property protection and the strategic options of technology owners.

While there seems to exist a significant amount of technology transfer activities among firms and institutions of developed countries, it also seems to be

a fact that, for licences in developing countries, the access to technology under favourable terms seems to be very difficult.

The licensing in biotechnology has taken various forms. Originally, biotech start-up firms would license their inventions to large corporations because they lacked capabilities to undertake successful market operations and needed financial resources to continue their R&D activities.

This situation changed as some biotech start-up firms followed the road of inventing, developing and marketing the products themselves. On the other hand, large pharmaceutical companies decided to upgrade their in-house expertise by recruiting outside specialists or taking over smaller start-up firms.

Important sources of technology are also the universities which can have their own technology licensing programmes or otherwise conduct research under the sponsorship of governments or large corporations.

There has also been a tendency among specialised firms to form strategic alliances with other enterprises that have certain assets to offer in exchange, e.g. technological capabilities, financial resources or market access.

Licensing fees in biotechnology are usually higher than in many other industrial sectors. Royalty rates can range from 5-10 per cent for therapeutic products (monoclonal antibodies, cloned factors etc.) or even higher 12-15 per cent for approved or approved recombinant pharmaceutical. These are all issues which finally have to be debated and decided by WIPO.

The Keystone International dialogue Series on Plant Genetic Resources, at its Session held in Oslo in June 1991 under the chairmanship of Dr. M.S. Swaminathan concluded as follows with reference to plant breeders' and intellectual property rights.

Concerns have been expressed that the application of intellectual property rights to the successes from biotechnology research in developed countries could

have negative consequences for developing countries. The Keystone Dialogue group discussed the question what will be the net impact in economic terms of extending IPR to biological materials and of privatizing resources that were previously freely available.

a. Evolving international IPR activities

Legislative activities at the international level will have a significant influence on the availability of intellectual property rights in developing countries. These activities include the ongoing General Agreement on Tariffs and Trade (GATT) negotiations, the recently concluded revision of the International Union for the Protection of New Varieties (UPOV) Convention, and the patenting of plant-related biotechnological inventions.

In the absence of the GATT negotiations, the revision of UPOV and plant biotechnology patents might assume less significance for the developing countries and the survival of their plant genetic resources. However, as part of the Trade-Related Intellectual Property Issues (TRIPs) negotiations of the current Uruguay round of GATT, developed countries are pressing the developing countries to implement stronger intellectual property rights for a much broader range of materials.

If the GATT negotiations result in the strengthening of IPR within developing countries, this, in turn, might result in both the adoption of plant variety protection systems and the patenting of plants, animals, and the genetic materials that are contained in them. The Dialogue group expressed strong concern about the imposition of IPR for plant genetic materials through the GATT or bilateral trade negotiations. Every country has the right to decide whether and to what extent they adopt IPR for PGR. No country should be pressed to do so. To date, the issue has received little attention and discussion by the GATT negotiators. The Dialogue group strongly recommended that the implications of IPR for PGR be given adequate discussion and evaluation by the negotiators, with input from national experts and other entities involved with PGR such as FAO, UNEP,

UNESCO, UNIDO, World Intellectual Property Organization (WIPO), UPOV, and several NGOs, before any GATT action is taken.

Intellectual property right (IPR) systems have been instituted by many countries to varying degrees in order to stimulate innovation throughout all sectors of society and especially to promote investment by and secure rewards for the private sector. They are meant to provide an incentive to create innovation and to disclose its details.

There is little doubt that IPR systems under certain economic conditions are capable of encouraging innovations which may contribute to improvements in productivity. However, it is not possible to predict how those productivity gains might be distributed. If IPR systems are extended to plant genetic resources, depending on the precise nature of subject matter that qualifies for intellectual property protection and the scope of protection ultimately granted, some parties will be limited in their access to the protected germplasm. Developing countries have been the principal sources for PGR, but the poor farmers in those countries are most likely to be at a disadvantage without construction of proper safeguards.

The Keystone Dialogue group reviewed these issues and the status of certain international activities in these areas. This review has proven especially complex for several reasons. There are significant differences in structure and complexity among the agricultural systems in developed and developing countries, the definition of protected subject matter as it applies to biological material is still evolving and far from fixed even in developed countries, and specific legal provisions in the area of intellectual property rights for biological content are currently under consideration.

b. Physical Property and Intellectual Property

In the context of a discussion on PGR ownership, the Keystone Group felt that it is important to distinguish between property in the physical plant genetic resource (e.g., seed) and intellectual property. A seed is a tangible asset or resource which can be sold. Intellectual property is an intangible asset, such as

a patent or Plant Breeders' Right (PBR), recognized by society which grants certain rights for its exclusive exploitation. There are significant differences in the strategies used to control and manage each and in the nature of their impact on access to the plant genetic resources.

Based on past events and current policy, most countries have serious concerns about guaranteed access to plant germplasm collections, especially those that originate in their country and are stored in another. It has been formally recognized by the FAO Undertaking on Plant Genetic Resources that the world's plant genetic resources are part of a global heritage which should be accessible to anyone who has need of it for plant breeding and scientific purposes.

The Keystone Dialogue group recommended that every effort should be made to minimise all restrictions on the access to germplasm, from any quarter. Nevertheless, it is recognized that breeders' lines can remain outside the full exchange relationship in order to allow breeders to complete their work and make a formal varietal release. In the same way, there exist other genetic resources, improved or unimproved, for which there may be a reason for temporary constraint to exchange. In such cases, the world community must yield to the judgement of the holder of the germplasm.

At the November 1989 FAO Conference, all member countries endorsed an agreed interpretation of the Undertaking that recognizes both Plant Breeders' Rights and Farmers' Rights. Plant Breeders' Rights are a formal system for rewarding developers of plant varieties. The principle of Farmers' Rights recognizes the fact that farmers and rural communities have contributed greatly to the creation, conservation, exchange, and knowledge of genetic and species utilization of genetic diversity. This interpretation aims at reconciling the view of the "technology-rich" and the "gene-rich" countries in order to ensure the availability of PGR within an equitable system.

The concept of Farmers' Rights emphasizes the importance of the contribution of farmers and rural communities to "...the creation, conservation, exchange, and knowledge of genetic and

species utilisation of genetic diversity; that this contribution is ongoing and not simply something of the past; and that this diversity is extremely valuable".

Currently, no formal recognition and reward system exists to encourage and enhance the continued role of farmers and rural communities in the conservation and use of plant genetic resources. This concern should be considered within the context of the Dialogue group's recommendation regarding a Global Initiative for the Security and Sustainable Use of Plant Genetic Resources, which includes the establishment of a PGR Trust Fund.

The topic of ownership and use of genetic resources is currently under discussion at the inter-governmental level as a part of a global biodiversity convention being negotiated under the auspices of UNEP.

c. Biotechnological Exploitation of PGR

The call for equitable compensation for the use by biotechnologists and other scientists of plant-derived genes is likely to increase as improved plant varieties and other products developed by the new technologies reach the marketplace within the next few years.

Although compensation usually is discussed in financial terms, there are other ways that developing countries may obtain a reciprocal benefit for their contribution. Access to genetically engineered germplasm for local breeding, or to gene constructs for transfer into indigenous crops, are two mechanisms of compensation. An example can be cited in the case of rice.

1.11 Some directions of biotechnology research

The International Service for National Agricultural Research (ISNAR) convened a consultation in May, 1991, which helped to identify directions for biotechnology research during the nineties. The following are some of the conclusions arrived at this meeting.

Biotechnology can be represented as a gradient of technologies, starting at a relatively simple level with tissue culture and rising sharply through recombinant DNA to the genetic engineering of plants, animals and microorganisms (fig.1). Plant breeders have based their work on biotechnology since they adopted the principles of genetics, first outlined by Mendel in 1866. New techniques, based on recombinant DNA technology, monoclonal antibodies, and novel methods of cell and tissue culture, which are arousing such widespread interest today, should be labeled "modern biotechnology".

There is no debate over whether developing countries should start moving up the gradient: the more richly endowed national systems are already well on the way. Even the smallest and poorest should be thinking about a "survival kit" based on modern techniques. For instance, a country where root crops are a staple food could profitably invest in a tissue-culture laboratory. At a capital cost of about US\$ 10,000 this would permit the importation in tissue culture of virus-free clones developed in research stations abroad, and their rapid multiplication if they prove adaptable to local conditions and acceptable to producers and consumers.

Further up the gradient, the issue for decision is how far a national system should develop its own in-country capacity in modern biotechnology, and how far it should rely on access to outside institutions. This will to some extent be a political matter. If the main concern is for export crops, countries may well be influenced by the atmosphere of high international competition for markets, and go for the maximum in-country capacity they can afford. They will, however, have to bear in mind that the costs of the new techniques are falling continuously as new methods and new machines are devised; they will need to take precautions against locking themselves into a highly expensive approach that may become obsolete within a very few years.

The development of biotechnology will increase the load on traditional plant breeding programme. since only practical breeders can effectively test the new varieties that may emerge from the laboratories. Indeed, the existence of a traditional plant breeding programme is a pre-requisite for a successful move up the gradient of biotechnology in the area of crop production.

Current technology can modify a single gene on a chromosome. Major break-throughs will require more complex transfers. For instance, transferring the ability to fix atmospheric nitrogen to cereals (and thus limiting the need for nitrogenous fertiliser) involves at least six genes. **Longer-term progress will depend on further advances in basic science, notably in such areas as the mapping of genomes.** Among possible research objectives, priority might be given to efforts to increase the total biomass of a given crop, and at the same time to improve the partitioning between food and nonfood components.

Patents are now granted in some countries belonging to the Organisation for Economic Cooperation and Development (OECD), notably the USA, for genetically manipulated plants, animals microorganisms, and related biotechnology processes. In the OECD countries as a whole, about half of the work on modern biotechnology is being done in the private sector. The question of access to new technology on the part of developing nations is thus a highly important one. National legislation on intellectual property rights will become necessary for access to patented technology held abroad, as well as for protecting the commercial value of discoveries made at home. In negotiating access, a developing country will need to be well informed or well advised. It should also have a clear idea of who, initially and ultimately, is going to pay for commercially acquired technology. International and regional mechanism will have to be developed for providing such know-how.

Concerns about biosafety are high on the international agenda. No country will wish to enter the field of recombinant DNA without having in place adequate mechanisms for ensuring the safe release of genetically modified organisms. Considerable experience is accumulating in risk assessment, and it can be drawn upon by new national systems.

There is also concern to ensure that the end results of modern biotechnology are socially benign. The Green Revolution was accused because of a failure to distinguish between the roles of science and of public policy of indifference to the fate of small farmers. It will be necessary to undertake proactive social research from the earliest phases to avoid the same charges being leveled again. Bringing

biotechnology to bear on "orphan commodities" that are important to small farmers as either food or cash crop is one way in which benefits could reach those most in need of them, although this will require major institutional changes in how science supports such developments.

Opinions are divided on whether modern biotechnology should be the subject of a specialized institution or slotted into existing research organisation. Clearly, it is a set of new tools for research, rather than a new discipline. In most instances, integration of the new techniques into the existing NARS and university research programme will have the most beneficial, long-term effects on the development of science within a country. At the same time, it involves policies (on property rights, biosafety, etc.) that fall outside agriculture. For this reason, there is a powerful case for creating a national committee or commission to bring together the various sectors concerned in order to develop a national policy on the application of biotechnology to agriculture. Large countries like India have addressed this issue by creating a separate Department of Biotechnology in Government.

How far will the new techniques be translated, over the next twenty years, into actual yield increases in farmers' field? This is a question to which only the most tentative answer can be given.

Progress will obviously depend, in the first place, on the ability of scientists to produce results. Practical impacts in such areas as diagnostic tools and vaccines can already be seen, and this is likely to strengthen over the shorter term. More far-reaching progress in gene enhancement could arrive within a decade and could have a major impact on the production figures between ten and twenty years hence. It seems likely that new technology will, for certain commodities, reduce the length of the "product cycle" in agriculture, just as it has in industry.

More rapid methods of testing, reproducing, and diffusing new varieties, new vaccines, or new types of inputs should permit their widespread use much more quickly than we have hitherto seen. Extension to farmers should be no problem

if the new product offers a truly significant increase in profitability. Progress could thus be rapid, once new technologies have been developed and their cost, risk and return structure demonstrated to users.

One needs to recall, however, that we are dealing with two variables: the rate of progress in basic science and the rate at which discoveries can be translated into widely usable technologies. Peering into the future beyond the next five years yields speculations, not predictions. Caution must be the watch word.

The annex contains a case study of rice illustrating attempts made to impart a pro-poor bias in biotechnology research and application.

1.12 Pro-poor biotechnology research and IPR

The Rockefeller Foundation programme on rice biotechnology, was cited earlier as an example of a pro-poor biotechnology programme. Hence, it may be useful to indicate the policy guidelines regulating this programme.

The goal of the Rockefeller Foundation's International Programme on Rice Biotechnology is to apply advanced biological technologies to rice production in developing countries for the benefit of low income rice producers and consumers. The research supported is expected to contribute, through a series of cooperative projects and transfers of technology, to the production of improved seed and other materials used by farmers.

Mechanisms are in place, coordinated by the International Rice Research Institute (IRRI) and the Centro Internacional de Agricultura Tropical (CIAT), which facilitate the free exchange and distribution of rice breeding lines. Improved varieties ultimately reach the developing-world farmer either through public sector distribution or through commercial varieties. In general, the developing world farmer should have access to varieties at the lowest possible price and should pay no royalties, or at most nominal royalties. If there is exclusivity at this level, it should be only to facilitate effective distribution.

It is expected that Rockefeller Foundation rice biotechnology grantees will share materials and technology resulting from Foundation-supported research with cooperating researchers at zero royalty for use in developing countries. Grantees should not enter into agreements that conflict with this obligation. If such agreements are already in place, the Foundation should be so informed. This policy covers intermediate steps such as research results, transformation procedures and rights under material transfer agreements as well as final products and rights under patents or other forms of intellectual property.

At the same time, it is recognized that grantees may wish to pursue intellectual property rights on their discoveries and their improved materials in order to obtain economic return in developed countries for the support of further research and to maintain a strong bargaining position in the event of any intellectual property disputes.

Collaboration and the free exchange of research materials are hallmarks of the rice biotechnology network and contribute much to its success. In many cases materials are shared and technologies transferred prior to publication. Such principles need consideration when research programmes designed to promote household nutrition security among the poor are designed and funded by national, bilateral and multilateral agencies.

The CG-Biotech proposed in the last section of this paper should develop similar procedures in the case of all biological organisms of interest to global food and ecological security. Such mechanisms will help to harmonise the need for incentives for private investment and initiative in biotechnology research and for promoting public good.

ANNEX

Imparting a pro-poor bias in biotechnology research and application: Case study of rice

If it is agreed that development which is not equitable will not be sustainable in the long run, it is important that attention is given to the integration of the principles of equity with those of economics and ecology in the design of new technologies. It is now widely recognized that the realization of the pro-poor potential of biotechnology depends on the priorities of research. Rice biotechnology illustrates how a pro-poor bias can be imparted in investment decisions.

In 1984, the International Rice Research Institute (IRRI) organised a conference on Biotechnology and International Agricultural Research. Stimulated by the results of that conference and by the fact that a crop like rice, where the output is largely utilized for consumption by those producing the crop, is unlikely to attract attention from commercial biotechnology companies, the Rockefeller Foundation funded an International Programme on Rice Biotechnology.

Toennissen and Khush (1991) have recently summarized the major accomplishments of this project. Since the results obtained in rice within a span of five years are indicative of the power of both the tools of biotechnology and of methods of organization of research, it may be useful to quote the conclusions of Toennissen and Khush (1991).

Rice breeders face a major challenge of producing rice varieties for diverse environments in which the crop is grown. These varieties must have increased yield potential, superior grain quality, resistance to diseases and insects, and tolerance for abiotic stresses. Plant breeders have always used the best available technology to achieve such breeding objectives but perhaps no other innovation has facilitated plant breeding work as much as the recent breakthroughs in biotechnology.

Plant breeding involves two phases:

- * The evolutionary phase where variable populations are produced. The time-tested methods used to create variability are hybridization and, to a lesser extent, the induction of mutations.
- * The evaluation phase where desirable genotypes are selected from the variable populations. Various methods, such as bulk population breeding, pedigree selection, recurrent selection and single-seed descent, are used to identify desired genotypes. The yield performance of selected genotypes are then evaluated in replicated trials.

The tools of biotechnology will not replace - and are not intended to replace - any of the time-tested methods of crop improvement. Rather, biotechnology techniques either increase the efficiency of various methods of plant breeding, or allow breeders to accomplish objectives that cannot be achieved through conventional plant breeding. For example, wide hybridization through embryo rescue or somatic hybridization, somaclonal variation, and genetic engineering are useful in the evolutionary phase. The selection efficiency with doubled haploid lines produced through anther culture of F-hybrid is higher due to absence of dominance variance. RFLP markers, when used to tag genes of economic importance, can aid the selection process and increase its efficiency. The marker-based selection holds particularly high promise for quantitative traits and those that are difficult to evaluate with presently available techniques. Nucleic acid probes and monoclonal antibodies are proving of great value in selection for disease resistance.

Perhaps the most important contribution of biotechnology will be in adding alien genes to the gene pools of the crop species through genetic engineering. The elegant techniques for gene identification, gene cloning, and transformation allow introduction of genes from any living organism to another where it imparts a useful function. Such gene transfers are beyond the capability of conventional breeding methods. The following are some areas of immediate impact:

a. Wide Crosses

Rice biotechnology is already contributing to the production of improved varieties. Wide-cross hybridization, including use of embryo rescue techniques, has allowed the transfer of useful genes from wild *Oryza* species to elite cultivars. Many more potentially useful genes remain available in the wild species and new tools from biotechnology will speed their utilization. RFLP maps and species-specific DNA probes will enable rice breeders to more effectively follow the introgression of alien chromatin from wild species to elite lines. Using *in situ* hybridization of these probes and scanning electron microscopy, it is even possible to visualize the alien chromatin on the rice chromosomes.

As protoplast regeneration protocols become more efficient and available for a broader range of rice cultivars, protoplast fusion followed by regeneration should become another technique for wide crossing. It can be anticipated that numerous genes from wild relatives will be used to transfer useful new traits in rice in the coming years.

b. Anther Culture

Anther culture allows the production of homozygous plants in two generations and can reduce the time required to produce new rice varieties. The gametic genotype, including recessive genes, is expressed and early generation selection becomes feasible due to the additive effect of the doubled haploid lines and the elimination of dominance variance. Anther culture of rice has been proven effective and several varieties have been released in China using this method. It is likely that this technique will be more broadly utilized, particularly in locations where only one generation per year is feasible for conventional breeding. Anther culture should also enable greater utilization of minor genes for resistance, the cumulative effect of which may provide more durable resistance than that provided by major genes. Further theoretical and empirical research aimed at improving the anther culture response of indica rice is under way and should help advance application of this valuable breeding tool.

c. Maps, Markers and Gene Tagging

Rice is particularly well suited for DNA-based genetic mapping. It is a true diploid with a small genome having ample polymorphism and it is highly recombinogenic. There are major RFLP mapping programmes under way at public sector institutions in at least four countries, and gene tagging studies are being done in numerous locations worldwide. The maps and markers are shared and made freely available to any scientist. The International Rice Research Institute is facilitating collaboration, coordination, synthesis of results, and integration of the RFLP map with the classical map. Both IRRI and the International Centre for Genetic Engineering and Biotechnology (ICGEB) in New Delhi are making progress toward the development of non-radioactive probes that would enable routine use of RFLP markers in rice breeding programmes.

By combining the independently developed RFLP maps of rice, a densely saturated map should soon be available. In tagging experiments this will allow identification of markers that are closely linked to the genes responsible for any trait that can be scored. For complex traits (such as drought tolerance) the markers can then be used not only to follow inheritance of major genes, but also as an analytical tool for dissecting the trait and identifying its major physiological and biochemical components.

The RFLP map soon will be sufficiently dense to allow chromosome mapping and map-based cloning of rice genes. Thus, it should soon be possible to clone rice genes with a known phenotype but an unknown function.

The maize Activator (Ac) element was recently transferred to the genome of rice plants and shown to transpose. Assuming transposition continues to occur in progeny plants, transposon tagging will also be available for cloning rice genes of unknown function. These methods will enable important genes, such as those controlling pest resistance, to be cloned and their function studied at the molecular level. A wealth of knowledge concerning biochemical and physiological mechanisms should result and strategies for useful modification of these genes should emerge.

d. Genetic Engineering

Several laboratories have established the capacity to produce transgenic rice plants via protoplast uptake of DNA followed by plant regeneration. For some japonica cultivars, transformation efficiencies have improved significantly and numerous transgenic plants can be produced. Transfer of transformation protocols from one laboratory to another is also occurring. A variety of interesting rice gene constructs are being tested for research purposes and to evaluate their potential usefulness.

Steady progress is being made towards developing protoplast- based transformation protocols for indica rice but efficiencies remain low. There are unpublished reports of genotypes- independent transformation of Indica and Japonica rice using particle bombardment and of transgenic rice plants produced via Agrobacterium vectors. Within a few years one or more of these transformation techniques should be sufficiently routine to enable rice biotechnology laboratories to establish a transformation capability for any rice cultivar.

Homologous recombination was recently reported in plant cells following Agrobacterium mediated transformation suggesting that allelic replacement of plant genes may soon be possible. Using particle bombardment, Svab et al. (1990) achieved stable transformation of the chloroplast genome. This opens the possibility of using chloroplasts as sites of alien gene expression and vehicles for alien gene delivery. While these results were in tobacco, further refinements will surely enable them to be repeated for other species, including rice.

Methods for the manipulation and transfer of large DNA fragments are being developed and will provide another set of valuable tools for plant genetic engineering. This includes experiments aimed at transforming plant protoplasts with large DNA fragments (200-500kb) cloned in yeast artificial chromosomes (YACs). If successful, it should then be possible to transform rice with YACs that carry DNA fragments shown by RFLP mapping to contain useful genes.

Scientists are beginning to experiment with concepts for producing artificial plant chromosomes. While still at an early stage of exploration this is a realistic research objective with significant potential for further strengthening plant genetic engineering.

e. Useful Genes

Thus, new tools are becoming available for identifying and cloning rice genes. In addition, a major international research programme has been launched designed to obtain the complete genetic sequence of the flowering plant *Arabidopsis* and to identify and clone many of its genes. The combination of RFLP mapping and transposon tagging in maize is also leading to the identification and cloning of many genes. These genes, or modifications of them, may confer useful traits if transferred to rice and in most cases they can be used as heterologous probes for isolating the analogous gene from rice. The coding and regulatory sequences of these genes will provide a substantial and valuable source of raw materials for rice genetic engineers. Over the next 10 years numerous genes worthy of testing in rice should become available.

From the foregoing survey of Toennissen and Khush (1991) it will be obvious that the prospects for the future of rice biotechnology are extremely promising. The scientific understanding that underlies the technology continues to advance rapidly, allowing constraints to be overcome and the technology to be strengthened. In Japan for example, a Rice Genome Advisory Committee was constituted in 1990 for promoting the mapping and sequencing of the rice genome.

Rice Genome Cooperative of Japan: The progress made in improving the yield potential of rice during the last two decades is shown in figure 2. Research institutions in rice-growing countries are now at the forefront of applying new technologies and they have the scientific capacity to further advance it. Before the end of the century, rice producers and consumers should begin to reap the benefits. Thus, this international collaborative project provides evidence of the usefulness of organised cooperation among basic and applied scientists and of the power of a multi-pronged strategy for achieving the desired goals speedily and surely.

CHAPTER II

Biotechnology and sustainable development: Contributions of the UN system and other international organizations

United Nations entities and programmes

Many organizations of the UN have programmes/activities relating to the application of biotechnology in agriculture, industry and medicine. There are also several inter-governmental and non-governmental organizations at global, regional and national levels concerned with biotechnology to a greater or lesser extent. The scientific and technological aspects as well as the social impact of new technologies are receiving attention. The work is so extensive that it will be difficult to do justice to the wide spectrum of activities currently in progress in a brief paper. Nevertheless, it is important to refer to a few highlights, however inadequate the summary may be. The source of information in most cases is the summary of their work sent by the respective organizations to UNIDO.

2.1 Office of the Director-General for Development and International Economic Co-operation

It has been suggested that action be directed to the following:

- (a) Harmonization and codification, so that a wider use could be made of what has been agreed upon; and
- (b) The impact on socio-economic issues, with particular emphasis on employment and transfer of technology - including funding for such transfer.

The UN system, it was concluded, and in particular UNIDO, could play a greater role in this area through dissemination of information and awareness on the most important issues in the field of biotechnology.

2.2 Centre for Science and Technology for Development (CSTD)

The work of the Centre for Science and Technology for Development (CSTD) on biotechnology is undertaken within the framework of the Advanced Technology Assessment System (ATAS). It began its work in the early 1980's with the publication of the first ATAS Bulletin, which carried out an assessment of tissue culture and development. Biotechnology has also figured as a part of an analysis of new and emerging science and technology (NEST), and then in a workshop on the commercialization of biotechnology in developing countries, held in Rio de Janeiro, Brazil, in 1988.

In 1990, the Centre began what it plans to be a series of regional and national level workshops on biotechnology for development. The first of these took place in Dakar, Senegal, on biotechnology for food production in dry areas. A second workshop was organized in Hanoi, Viet Nam, in December 1991, to assess biotechnology for food production and food processing in Southeast Asia, with particular emphasis on the needs of Viet Nam.

The CSTD considers the following to be both important and possible regarding action to be taken by the United Nations system in the field of biotechnology:

- (a) The organization of national "dialogues". (The CSTD is now organizing such country dialogues through its Programme of Endogenous Capacity Building;
- (b) Technology assessment;
- (c) Promotion of linkages;
- (d) Provision of the latest information on the organization and production of biotechnologies world-wide;
- (e) Assistance to developing countries by using its good offices to devise biosafety guidelines appropriate to developing countries and to develop equitable arrangements in respect to issues of accessibility of biotechnology;

- (f) Co-ordination of work in biotechnology in order to provide the developing countries with a consistent and cohesive set of measures to be undertaken to use biotechnology as a tool for development.

The CSTD considers that the ATAS has an important role to play in the above activities.

2.3 United Nations Conference on Trade and Development (UNCTAD)

UNCTAD prepared a report for the Committee on Transfer of Technology entitled "Trade and development aspects and implications of new and emerging technologies: The case of biotechnology" (document TD/B/C.6/154, dated 11 march 1991). This report draws on research from a larger study on agricultural biotechnology, presently being carried out jointly by UNCTAD and UNIDO. Some relevant aspects are summarized below.

The actual, as compared with the potential generation and diffusion of biotechnology and its applications, depends on the complex interaction of an array of not only technical, but also economic and institutional factors. The growing relative importance of private as compared to publicly-funded agricultural R&D, are some of the present trends. Moreover, in so far as they do not participate in the emerging networks of manufacturers, research laboratories and public institutions engaged in the development of biotechnological innovations in industrialized countries, the developing countries are missing out in the generation and sharing of knowledge relevant to their needs and in the negotiation of licenses under favourable terms that takes place among the participants. The "privatization" of the knowledge produced by biotechnological research contrasts with the openness and incitement to widespread dissemination of the results of largely publicly-funded Green Revolution research that contributed so much to agricultural productivity in many developing countries.

The drive to extend the scope of intellectual property rights protection of biotechnology through reform of industrial patent and/or plant breeder's rights legislation could accentuate these tendencies, particularly if it were left to a proscription of the existing rights of breeders to use protected plant varieties for the creation and commercialization of new varieties.

Unlike chemical or mechanical engineering, advances in agriculture are not readily transplanted from one locale to another without considerable investment in adaptation. However, except for a handful of major tropical exports, the private sector in developed market-economy countries has little commercial incentive to invest in the adaptation and transfer of biotechnology innovations to agriculture in developing countries. Hence, the ability of most developing countries to realize the potential offered by biotechnology for their agricultural production and exports will depend in part on the size and quality of their investment in adaptive R&D.

A major challenge facing developing country governments and the international community will be how to devise channels and mechanisms for the transfer of useful biotechnologies from private enterprises in developed market economies to developing countries and for the meaningful involvement of these countries in the research networks in biotechnology involving enterprises that are being formed in the developed market-economy countries.

Special attention will need to be given to the promotion of research for a range of crops important to developing countries, but not grown in developed countries - including a number of widely consumed cereals, pulses and food crops as well as some export crops - in which the private sector in developed market-economy countries has no commercial interest.

There is a need to study more carefully how different types of reform of protection of intellectual property rights would achieve the aim of stimulating invention and promoting technology transfer and co-operation in the area of biotechnology, particularly in developing countries, before agreement is reached on the adoption of uniform international standards of protection of living material. A related issue meriting study is the corresponding protection of the traditional crop breeding by farmers in developing countries that has never been remunerated as such and which could serve as a means of conserving plant genetic resources.

2.4 United Nations Centre on Transnational Corporations (UNCTC)

The views of the UNCTC on the contribution of biotechnology to sustainable development and the role of transnational corporations in this process are amply

Specialized agencies and other organizations in the UN System

2.8 Food and Agriculture Organization (FAO)

Biotechnology is just beginning to contribute to sustainable agricultural and rural development through aiding (i) development of pest and disease resistant clones/varieties/ breeds; (ii) freeing otherwise desirable planting materials of pathogens and enabling their rapid multiplication; (iii) use of monoclonal antibodies for precise and efficient diagnostics and for safe and specific treatment/control, viz. use of tailored vaccines in animal production (it is hoped that current advances in rinderpest vaccine production may offer a more convenient thermostable delivery system which will be extremely handy for use in remote areas in developing countries); (iv) use of efficient nitrogen-fixing mechanisms; (v) development of crop varieties efficient in mineral utilisation and tolerant to marginal areas; and (vi) use of genetically engineered microbes for degradation of wastes and breakdown of toxic residues.

Biotechnological applications will further promote sustainability through, among others, diversification of agriculture, forestry and fisheries production systems, supplementing genetic resources and developing life forms to fit in hitherto unthought of agro-ecological patterns, reducing environmental and economic risks.

The above applications are still extremely limited and the potentials have barely been exploited. The applications are being held in check by need for still more research to identify more useful genes and their effective expression in the transgenics, and to ensure that benefits do not entail harmful effects and pose biosafety problems.

At the national level, FAO is assisting several relatively well positioned developing countries to assess the requirements and to prepare the way through institutional and human resources development for undertaking research with special emphasis on the integration of biotechnology. In some instances assistance has focused on biotechnology for crop improvement, in others for production of vaccines and use of diagnostics (with involvement of the Joint FAO/IAEA Division) in livestock health and reproduction programmes.

Regional cooperation networks have been promoted under FAO guidance, viz., the Asian Network for Biotechnology in Animal Production and Health. A similar network for Latin America and the Caribbean and an Asian Network on Plant Biotechnologies are in the offing. A network for the Computer Assisted Analysis of Nucleic Acids and Protein Sequences (CAANAPS) in Latin America and the Caribbean covering seven countries and to be linked with similar European networks, has been initiated. A separate network on preparation and distribution of diagnostic probes/monoclonal antibodies for rapid diagnosis of livestock and poultry diseases in the same region is being established. Initiatives are planned for other region also.

Several expert consultations organised by FAO to prepare the ground for cooperative networks in animal production and health have recommended approaches and steps for FAO in this field. A quarterly bulletin, "Animal Biotechnology", contains information extracted from AGRIS, and initiatives to extend coverage in depth to other fields and in additional forms, are under consideration. Regional expert consultations were held in the Asia-Pacific Region in 1990 and 1991 to establish a cooperative network on plant biotechnology.

At the global level, most of the questions are being treated through the International Undertaking and the Commission on Plant Genetic Resources, for the collection, conservation and utilisation of germplasm. Elements, for a Code of Conduct on Biotechnology as it affects conservation and use of plant genetic resources, were prepared and submitted to FAO governing bodies. Collaboration with other UN Agencies is underway, as well as with NGO's, e.g. the UNIDO/WHO/UNEP/FAO Informal Working Group and OECD, the World Bank, IUCN, WWF and the European Community, on bio-safety.

As regards biosafety, although several studies have concluded that careful design of transgenic organisms, alongwith proper planning and regulatory oversight, will ensure that GMOs will pose little or no risk, risks are evident if pathogenicity is involved and calls for caution. The Fourth Session of the FAO Commission on Plant Genetic Resources, held in April 1991, resolved that FAO, in collaboration with other concerned organizations, should develop a Code which included and promoted basic biosafety standards for the contained use and deliberate release of GMOs, and for their importation and exportation. The Code

2.10 International Labour Organisation (ILO)

ILO has been concerned with an analysis of the implications of biotechnology on employment. ILO has also been promoting non-governmental organizations in spreading new technologies in rural areas. Dr. Iftikhar Ahmed of ILO has recently prepared a comprehensive book on "**Biotechnology: Hope or Threat**". He has compiled information on the potential impact of genetic engineering on employment opportunities (Table 5).

An ILO study on the targetting of endogenous capability in Latin America is now in progress and looks at the potential impact of biotechnology, substitutions and public-private sector roles. These issues are linked to the impact on various categories of producers, consumers and the labour market.

Biotechnology, including gene technology, is considered to offer immense potential to society by contributing to improvements in health, agriculture and industrial production. There is, however, growing concern regarding safety and health problems associated with biotechnology; the concern is further intensified by the expected rapid growth of these activities. Biotechnology is increasingly used for producing a variety of medicinal and agricultural products, to alter, for example, the resistance of agricultural products to physical and biological damage. A study is therefore being prepared by the ILO on the impact of modern biotechnology, including gene technology, on workers' health and the environment. The study will identify potential risks related to the introduction of these new technologies and will serve as a basis for future work on preventive measures.

2.11 United Nations Scientific, Educational and Cultural Organization (UNESCO)

UNESCO is actively involved in promoting several areas of biotechnology research and application. The general approach of UNESCO to this problem is that there is an urgent need for the transformation of the existing science and technology systems of developing countries to respond to the challenges and opportunities offered by new technologies in general and biotechnology in particular.

UNESCO took the lead in the establishment of a network of Microbial Resource Centres (MIRCENS - see Table 4) directed to the needs of developing countries. MIRCENS serve the microbial community in the collection, preservation, identification and distribution of microbial germplasm. They are also engaged in the dissemination of information relevant to the cultures and their uses, and in the development of research and training activities that are directed towards regional needs. UNESCO has seeded some efforts, through its global MIRCEN network and other arrangements, in promoting sub-regional and international co-operation, training and transfer and exchange of expertise in the biotechnologies field.

The goals of the programme are:

- (a) to provide a global infrastructure that incorporates national, academic and/or research institutes geared to the management, distribution and utilization of the microbial gene pool in the context of international cooperation;
- (b) to reinforce the conservation of micro-organisms, with emphasis on the Rhizobium gene pool in developing countries with an agrarian base;
- (c) to promote sustainable economic and environmental applications of microbial technologies;
- (d) to foster development of new inexpensive technologies native to specific regions;
- (e) to serve as a foci for the training of manpower and the diffusion of microbial knowledge.

Recently, within the framework of joint UNESCO/UNDP collaboration, the Biotechnological Information Exchange System (BITES) was established and comprises MIRCEN network partners that are linked to current relevant information systems. The focal point of BITES is the UNESCO International Centre for Chemical Studies in Ljubljana, Yugoslavia.

UNESCO has also instituted short-term fellowships in biotechnology.

Further, UNESCO is drawing attention to an important problem that arises from the development of new technologies. The internal dynamics of scientific development as well as the external dynamics of industries and other private actors in basic technological research, have created new controls over research systems and the choice of research priorities. This may lead to the situation where the interests of small agriculturists might be neglected when growing, for example, such crops as sorghum, a vital crop for many developing countries, since this crop is not an item of international trade and hence does not bring big profits to agricultural companies.

UNESCO has also instituted short-term fellowships in biotechnology. Integration of traditional and frontier areas of technology is being given high priority. UNESCO has suggested that concerns relating to bacteriological warfare should also be addressed, possibly through a high-level seminar, since the recombinant DNA technology provides scope for the synthesis of powerful biological warfare agents.

2.12 United Nations Industrial Development Organization (UNIDO)

Recognizing the potential of biotechnology for development and that the first order of its impact would be on industry, UNIDO initiated work 10 years ago on methods of identifying the effective transfer of benefits of biotechnology research to developing countries. This ultimately resulted in the establishment of the International Centre for Genetic Engineering and Biotechnology (ICGEB). The ICGEB has now 45 Member States and affiliated centres in 15 of these States. The research and development programme of ICGEB is dedicated to the application of genetic engineering and biotechnology to problems of relevance to developing nations of the world. The 1990 Activity Report of ICGEB gives an excellent summary of the work being done under its two components located at Trieste and New Delhi. The major thrust of ICGEB and its component units are as follows:

- Agribiology - with an emphasis on crop improvement
- Human health - with an emphasis on vaccine production
- Biomass conversion - lignocellulose degradation.

The ICGEB component laboratories are crucial to the success of the mission of the Centre in providing a world-class scientific milieu in which scientists can learn and apply new techniques and transfer them to their native countries. Through a process of consultation involving the Preparatory Committee, the Panel of Scientific Advisors (PSA) and scientists from the Member States, the above research topics were selected as being most in keeping with the declared aims of ICGEB.

(i) **Research at the Trieste component**

Under the development plan for the Trieste component, the full complement of research and support staff will by 1993 be divided into five research groups, each led by a senior scientist and composed of three to six junior scientists, plus a number of trainee fellows and technicians. These groups will address research topics in:

Virology, molecular and cell biology;
Immunology;
Pharmacology;
Protein structure and engineering;
Microbiology.

The group members will be drawn from a wide range of disciplines relevant to genetic engineering and bio-technology giving the Centre a multi-disciplinary character. The groups will interact and collaborate on the various facets of the research areas described above.

At Trieste, interaction with the local scientific community has already been established. Access to a very powerful source of X-rays from a synchrotron, to be operational by 1992, will enable ICGEB scientists at Trieste to pursue state-of-the-art research in protein structure and engineering.

(ii) **Research at the New Delhi component**

The research staff at the New Delhi component of ICGEB when at full strength (1993) will be divided into groups similar in structure to those at the Trieste component, each headed by a senior scientist and comprising a number

of junior scientists, trainee fellows and support staff. These groups will be active in:

- Plant biology;
- Human diseases;
- Structural biology.

The ICGEB has today become an extremely important institution with a global outreach through link centres. Its PSA comprises world leaders in biotechnology.

A number of technical cooperation projects in biotechnology have been implemented or are under implementation by UNIDO. An important example is the Regional Network for Biotechnology in Latin America and the Caribbean. UNIDO, with the financial assistance from the United Nations Fund for Science and Technology and UNDP, initiated in 1981 a preparatory phase of biotechnology activities in Latin America resulting in a regional programme and network.

Phase I of this programme funded by UNDP, was implemented jointly by UNIDO and UNESCO, with UNESCO covering the basic development of biotechnologies and products and UNIDO carrying out the technology development and industrial application of biotechnology. The programme's aim was to establish a framework for joint development policies in biotechnology, geared to solving regional priority problems through new products, processes and services. The programme's 13 country members formed a Regional Council as its top decision-making body. The Council selected nine biotechnology products of high regional priority, fostered training through training courses, workshops and fellowship programmes and identified 14 pipeline priority products and five priority areas not covered by the Programme. Phase II activities are under consideration by UNDP at present.

To complement the activities, the network has also been affiliated to the ICGEB. UNIDO also implemented technical assistance programmes in the region at national and regional levels.

Other activities undertaken through UNIDO's operational activities in applied biotechnology related to:

- biogas technology (industrial scale);
- ethanol production by fermentation from sugar, etc.;
- chemicals made by biotechnology processes such as amino acids, citric acid, enzymes, etc.;
- composting;
- assistance provided in biochemical engineering development;
- membrane technology;
- microbial pesticides;
- microbial leaching;
- plant tissue culture;
- waste water treatment, etc.

UNIDO's promotional programme in the field of biotechnology contains the following elements:

Programme element	Examples
(a) Identification of national and regional R&D priorities, monitoring of technological trends, sensitization of policy makers, scientists and technologists and the development of databases and bio-informatics networks.	Studies and policies and programmes in selected developing countries and on global trends in biotechnology etc. Development of a bio-informatics activity including a workshop in the USSR.
(b) National biotechnology policy formulation.	Biotechnology programmes in several African countries and advisory services under STAS.

2.13 World Bank

The World Bank has extensive programmes, particularly in developing countries, on various aspects of agricultural and industrial biotechnology and techno-infrastructure development. In recent years, considerable emphasis has been placed on integrating the concept of ecological sustainability with those of economic efficiency. In fact, the former President of the World Bank, Mr. Barber Conable said at a meeting at the World Resources Institute three years ago that if the World Bank was part of the ecological problems in the past, it would like to become a leader in the eco-development movement of today. The World Bank has also been increasingly supporting biotechnology research in developing countries and has appointed a Special Advisor to promote biotechnology research and applications.

2.14 World Health Organization (WHO)

The WHO has identified a number of specific areas for investigation to promote health care:

- Analysis of the structure and function of genomes of infection agents to better understand the process of infection and the mechanisms of pathogenesis and immunity;
- Preparation of monoclonal antibodies to identify constituents of infectious agents and the role of these constituents in pathogenesis;
- Identification and analysis of those antigens which elicit protective immune reactions, preparations of such antigens using recombinant DNA technologies or chemical synthesis and exploration of their use as vaccines;
- Development of reliable, comparable and easy to use procedures for the diagnosis of communicable diseases using monoclonal antibodies and defined and purified antigens;
- The development of specific anti-viral or anti-microbial compounds;

- Production of therapeutically active polypeptides, e.g. hormones and enzymes, of high purity;
- Identification of disease-specific hereditary traits providing a sound basis for genetic advice and for the development of genetic approaches to health promotion;
- Control and/or modulation of gene expression in diseases due to malfunction during differentiation;
- Genetic modification of biological control agents important in vector control;
- Identification of the oncogenes which are responsible for neoplastic transformation of cells, especially those that are involved in human cancer common in the developing world, such as primary hepatomas; development of DNA probes for the detection of activated oncogenes and of monoclonal antibodies against the corresponding proteins. Identification of specific tumour markers and development of reliable immunological assays.

Of these, it has been considered that three new techniques had the potential for early application. They were new approaches to vaccine development, improved techniques for diagnosis and the early detection of hereditary disorders.

There are four programmes in WHO, which have as a significant or main component the development of new or improved vaccines. They are the Special Programme for Research and Training in Tropical Diseases (TDR); the Diarrhoeal Diseases Control Programme (CDD); the Special Programme of Research, Development and Research Training in Human Reproduction (HRP); and the Vaccine Development Programme.

WHO has made considerable efforts to examine the potential of new diagnostic techniques, particularly those based on monoclonal antibodies, for use at the primary health care level. The potential of nucleic probes for rapid, sensitive diagnosis of infectious diseases is also to be noted.

Nucleic acid probes had already been used in the early detection of hereditary disorders, such as thalassaemia. If adopted universally and practised continuously, this approach might result in the eventual eradication of this and similar diseases. These techniques and technologies have been described in many articles both in scientific journals and WHO documents.

2.15 World Intellectual Property Organization (WIPO)

The work of WIPO is of great relevance to the question of gene and genotype patenting. It has convened three meetings of a committee of experts on biotechnological inventions and industrial property, and one of a committee of experts on the interface between plant protection and plant breeders' rights. The decisions taken by WIPO will be of particular relevance to South-North issues in biological diversity and biotechnology.

2.16 World Meteorological Organization (WMO)

WMO has been actively involved in programmes relating to climate change. The World Climate Programme has become an important source of reliable information on weather conditions. WMO has also established a global atmospheric watch (GAW) system to provide reliable assessment of atmospheric composition including carbon dioxide, ozone and other green house gasses. This knowledge is important for imparting stability and sustainability to production systems. WMO also trains personnel for national meteorological and hydrological services.

The second World Climate Conference organised by WMO in association with other UN agencies in October-November 1990 provided an updated and authentic picture of emerging trends in climate. Such information is relevant to biotechnology research since anticipatory programmes can be taken up for breeding strains of crops and farm animals capable of adaptation to changes in temperature, precipitation and ultraviolet-B radiation.

Information dissemination by the UN system

UN agencies are actively engaged in dissemination of information in the area of biotechnology particularly of relevance to developing countries. Some of the important activities in this area are the following:

The Advanced Technology Alert System, UNCSTD

The PANOS dossier published in 1990 by PANOS, prepared by Robert Walgate, now with WHO;

The training role of the Consultative Group for International Agricultural Research (CGIAR);

UNIDO's Genetic Engineering and Biotechnology Monitor;

The role of ICGEB as a network, "Helix" Newsletter and ICGEBnet;

The World Bank - CGIAR-IARCs network, linking to traditional agricultural research services;

UNESCO MIRCEN;

2.17 Databases

A number of databases have been established or are in the final stages of preparation. Others are under consideration or in early stages of development. The databases relate to regulation, introduction or releases, microbiology, molecular biology, cell lines and hybridomas, sequence data, bibliographic and general biotechnology information. The major databases are: OECD's Bio-track on the Use and Release of Organisms; culture collection catalogues (United States, European countries, Japan, Brazil) including the World Data Centre's Directory of Culture Collections of Micro-organisms; national and regional microbial strain databases (MiCIS, MINE in Europe); Hybridoma Data Base, Immunocline Database, Interlab Animal Cell Database; sequences databases (EMBL, Seqnet, Can/Snd, Gen Bank); botanic databases (ILDIS); taxonomic databases (Biosis, ICECC); plasmids/vectors/gene libraries (NIH Repository of Human DNA Probes); bibliographic (Datastar, Dialogue); general biotechnology (Bio-Industry Association databases, BIKE, BIOREP); Biotechnology Information Knot for Europe of GBF in Germany. Many of these are linked through the internationally sponsored information and communications Microbial Strain Data Network (MSDN).

In addition, a database containing information on national and international safety standards, training materials, studies and other publications concerning safety in the workplace in biotechnology is held in the International Occupational Safety and Health Information Centre (CIS) of the ILO. The future of biotechnology will involve reliance on large amounts of shared data and hence international agreements on data sharing are important.

Other international and regional organizations

2.18 Commission of European Community (EC)

The EC has a very active programme in the area of biotechnology. A Bio-Molecular Programme, and a Biotechnology Action Programme (BAP) have been in progress from 1982 and 1985 respectively. The Community has initiated some pioneer projects such as the following:

BAP pioneered the concept of "European Laboratories without Walls" and the involvement of "Industrial Platforms" of interested companies. Project BRIDGE (Biotechnology Research and Innovation for Development and Growth in Europe) supports programmes like the following:

- the characterisation of industrial lipases
- the sequencing of the yeast genome (starting with one small chromosome)
- the molecular identification of new plant genes
- the technology of lactic acid bacteria
- the regeneration of cultured plant cells.
- automated microbial identification
- animal cell biotechnology

Targeted projects will receive approximately half the programme's resources for cost-shared research contracts; the other half being devoted to N-projects (for "networking").

- (a) The SAGB projects the total value of biotechnology products and processes by the year 2000 at 83.3 billion ECU.
- (b) Biotechnology products and processes are expected to account for 8 per cent (weighted average) of all target markets by the year 2000.
- (c) Market sectors most highly impacted will be:

- Pharmaceuticals/health care
- Chemicals
- Agriculture
- Food
- Environment

The most advanced current commercial applications of biotechnology are in the chemical, pharmaceutical and instrumentation/electronic sectors, because the technical hurdles have been more rapidly overcome.

Commercial applications in food and agriculture will develop more slowly until the mid-1990's because significant technical hurdles must still be overcome.

2.19 Role of Regional Development Banks

In addition to the above, regional development banks like the Inter-American Development Bank, Asian Development Bank and African Development Bank are supporting activities in the area of biotechnology. ADB is supporting the preparation of pilot biovillage projects in Asia. This programme emerged from a Dialogue held at Madras, India, in January 1991 under the auspices of the M. S. Swaminathan Research Foundation on taking the benefits of biotechnology research to the rural poor. A biovillage is one where the best in modern biological technology is integrated with the best in traditional wisdom, tools and practices. Pilot biovillage projects are currently under development in China and India with ADB support (Swaminathan, 1991). Regional political groups such as ASEAN and SAARC have also been concerned with issues relating to biotechnology.

The Inter-American Development Bank has been looking for new approaches as well as more advanced strategic and modern technologies to better serve the member countries. The general orientation is now to emphasize agricultural development, taking into consideration conservation and management of natural resources and eco-regional development. This new orientation encourages the use and application of biotechnology and genetic engineering as components of the Bank's project, when relevant. The IDB is of the view that biotechnology efforts at national, regional and international levels has clearly helped some Latin American countries.

2.20 Non-governmental Organizations

The International Council of Scientific Unions (ICSU) has a working committee for biotechnology (COBIOTECH) which is focussing on discussions on biotechnology and sustainable development. COBIOTECH has been sponsoring regional and international symposia and conferences designed to discuss and promote opportunities for collaboration between East and West. National organizations have been the most important sources of activity within countries. Several of them have very extensive programmes. For example, the 25 May 1991 issue of **Current Science, India**, has an excellent summary of the state of biotechnology research in India.

The European Confederation of Biotechnology has been actively concerned with a large number of issues, including the legal framework for ensuring bio-safety.

2.21 European Biotechnology Information Service (EBIS)

EBIS is also an important source of news and views in the area of biotechnology. Various advisory groups functioning under the EC and EBIS give up-to-date information on their activities.

**United Nations Conference on Environment and Development
(UNCED)**

Agenda 21 of UNCED includes programmes relating to the speedy and effective transfer of environmentally sound technologies. In this connection, a workshop held in New Delhi, India, from 23-35 October 1991 has suggested the following five principal objectives and five major programme areas for inclusion in Agenda 21.

(i) Objectives:

- a. Increase food productivity in sustainable agricultural systems through the use of modern biotechnology applications in combination with conventional/traditional methods, techniques and technologies.
- b. Contribute to improvements in human health globally.
- c. Reduce environmental degradation, and preserve environmental integrity by the judicious application of biotechnology and facilitate the provision of safe, clean, reliable water supplies.
- d. Implement internationally-agreed safety procedures.
- e. Stimulate the development and transfer of bio-technology applications.

(ii) Programmes:

- a. Increasing plant and animal productivity.
- b. Promoting improved human health.
- c. Enhancing protection of the environment.
- d. Enhancing safety in biotechnology and developing international mechanisms for cooperation.

- e. Establishing enabling mechanisms for the environmentally sound application of biotechnology.

The PREPCOM III of UNCED considered the report of the Secretary General and agreed with the following objectives and activities:

Objectives

- a. Increase plant and animal productivity by 25 per cent by the year 2000.
- b. Reduce dependence on pesticides for food, feed and fibre by 25 per cent by the year 2000.
- c. Increase productivity on marginal lands through the use of nitrogen fixation and mycorrhiza and reduce dependency on chemical fertilizers.

Activities

The proposed activities of this programme include:

- a. Use of conventional technology and biotechnology to develop transgenic (genetically modified) plants that are resistant to biotic and abiotic stresses.
- b. Use of traditional techniques of nitrogen fixation and mycorrhiza in conjunction with advanced molecular biology techniques, to improve nitrogen fixation efficiency of symbiotic organisms in legumes and grasses, and phosphorous uptake capacity by crops.
- c. Use of conventional technology in conjunction with animal reproduction and animal health biotechnologies to accelerate animal breeding for specified needs and rescue endangered native livestock for breeding purposes.

- d. Provide adequate institutional infrastructure.
- e. Address issues related to germplasm resources, intellectual property rights, and harmonize bio-safety procedures.

2.22 Biotechnology and health for all

The protection and enhancement of human health is one of the most important objectives of development. The degradation of environmental quality, for example, by air and water pollution, soil contamination, toxic chemicals and hazardous wastes, is of increasing concern. There is also an increase in communicable and vector-borne diseases compounded by malnutrition, inadequate human settlements and lack of sanitation facilities. The health and well-being of people are therefore expected to be subjected to increasing risks, which in turn would affect the productivity and innovations of the individual.

a. Universal Immunisation

Develop new and improved vaccines against major communicable diseases that are efficient, safe and protect the individual with least number of doses. The vaccine should be stable to higher temperatures and preferably orally delivered. It should also be possible to combine and deliver a number of vaccines in a single dose for multiple disease protection at birth.

Control of disease vectors, such as mosquitoes, through the use of biological control agencies.

b. Development and use of specific diagnostics

Develop and utilise new diagnostics based on monoclonal antibodies and DNA probes for the early, accurate solution of various diseases for enabling prompt treatment.

Facilitate use of diagnostics under unsophisticated conditions by semi-skilled personnel.

c. **Development of new therapeutic and growth promoting agents**

Develop and facilitate the use of hormones and its agonistics and antagonists (e.g.) insulin, growth hormone).

Develop agents that promote cell growth and modulate immunity systems (e.g. cytokinins, TNF, ECG).

d. Development of new population control agents using natural body mechanisms and biotechnology leading to safe, reversible, and long-lasting methods.

e. **Development of new drugs** based on molecular designing:

Develop new pesticides and other chemicals designed through computer simulation and modeling using receptor-drug/receptor-pathogen interactions.

Develop new drug delivery systems to deliver drugs to target sites and which are useful in the treatment of problematic diseases and organs (e.g. cancers, brain tissues).

f. **Development of safe and effective methods of detection and treatment** of genetically inherited and inborn diseases using DNA probes and gene therapy.

The above are some of the priority tasks in the international research agenda proposed for consideration at UNCED.

2.23 Call of PREPCOM III of UNCED

The paper "Environmentally sound management of biotechnology: options for Agenda 21" dated 27 September 1991 (A/CONF. 151/pc/WG.1/L.30), prepared for the UN General Assembly with regard to the work of PREPCOM 3 for UNCED, brings out the significance of biotechnology for a better quality of life for all. The paper has stressed that the environmentally sound and safe application of biotechnology has the potential for addressing issues such as health care, levels of food security, the efficiency of industrial development processes, the purity of water supplies and environmental problems arising from water pollution, pesticide

residues and soil degradation. The paper has underlined the need to accelerate the development and application of biotechnologies, particularly in developing countries.

For this purpose, the paper calls for a major effort to build up institutional capacities at national and local levels, especially in terms of research and training, raising public awareness, the development of human resources and information facilities, matched by appropriate levels of financial support and backed by equivalent development and support for traditional methods and techniques as practised by local and indigenous communities.

The call for a major effort in the biotechnological transformation of the quality of life of rural and urban poor in developing countries needs for its realisation new patterns of international cooperation backed by appropriate institutional structures. It calls for action at the local, national, regional and global levels. It may be worthwhile to review some of the major components of a "Biotechnology for a better common future" programme.

CHAPTER III

International cooperation in biotechnology for a better common future

3.1 International cooperation: Need for a new vision

The cooperation has to be viewed at three levels:

- a. Technology: Development and dissemination
- b. Training: Degree and non-degree
- c. Trade: Home and international trade

The existing situation in these areas has been reviewed earlier.

A few suggestions are offered here for the further development of on-going collaborative efforts, both in the short and longer term perspectives.

- a. **Technology**: This is the prime mover of economic and ecological change, either for the better or for worse. In view of the dominant role of the private sector in the biotechnology industry of developed nations, it is difficult to suggest global mechanisms which will be considered satisfactory by all. However, the following steps will be relevant.
 - (i) Immediately, ICGEB already exists. Its research and training programmes have the support of scientists worldwide. In order to ensure that its research has the desired impact it would be useful to link ICGEB in global networks such as those operated by CGIAR institutions. Since ICGEB's activities also cover the medical field, it is important that it has symbiotic linkages with WHO's medical networks.

A list of CGIAR centres is given in Table 7.

The following centres of CGIAR have active programmes in agricultural biotechnology:

- a. CIAT, Cali (Colombia)
- b. CIMMYT, El Batan (Mexico)
- c. CIP, Lima (Peru)
- d. IBPGR, Rome (Italy)
- e. ICARDA, Aleppo (Syria)
- f. IRRI, Los Banos (Philippines)
- g. ICRISAT, Hyderabad (India)
- h. IITA, Ibadan (Nigeria)
- i. ILRAD, Nairobi (Kenya)

The New Delhi centre of ICGEB is already playing an active part in the international rice biotechnology programme. The specialised expertise of ICGEB will be of much benefit to the International Agricultural Research Centres (IARC's). In turn, ICGEB's work will find immediate application at the field level through the networks of IARC's. Hence, a suitable Memorandum of Understanding could be developed between ICGEB and CGIAR institutes.

(ii) **At the regional level**, several networks already exist, some of them with support from regional development banks. These networks should be designed to forge a trilateral partnership among academic and research institutions, private and public sector industry and user groups. It is important to have user representatives in coordinating committees so that fears about the environmental safety and wholesomeness aspects can be addressed effectively. Regional Development Banks and regional political structures could jointly promote the growth of government-industry-academe coalition for the purpose of promoting the field application of the results of biotechnological research.

(iii) **At the national level**, different countries have different mechanisms at the governmental level to stimulate and sustain bio-technology research and development. Such mechanisms should be sensitive to public apprehensions on issues relating to safety and equity. In case there is an overall mechanism for giving high level political consideration to sustainability issues, such as a Cabinet Committee on Sustainable Development, a standing committee of that body could

deal with biotechnology, biodiversity and sustainable development. Pioneer projects like the biovillage programme supported by the Asian Development Bank in India and China need urgent support (Swaminathan, 1991).

There is also a need for specialised genetic resources centres for assisting genetic engineers. For example, the Centre for Research on Sustainable Agricultural and Rural Development at Madras is establishing two specialised gene pools for use in recombinant DNA experiments. One gene pool deals with the assembly of candidate genes which can confer tolerance to sea water intrusion. Another gene pool is an assembly of genotypes having a bearing on sustainability factors, such as the following:

- * Germplasm of nitrogen fixing tree species and shrubs, stem-nodulating legumes like Sesbania rostrata, as well as of Azolla and blue green algae.
- * Plant species of importance in pest control including tree species, annual plants, fungi and bacteria which can serve as repellents of pests and those which control soil nematodes and weeds.
- * Germplasm of species which can enhance the efficiency of fertilizer use including Neem (Azadirachta indica) and other tree species whose seed cakes have a nitrification inhibition capacity.
- * Species which can help to prevent/reduce soil erosion and protect local food security, often referred to as ecological or economic key species, such as vetiver grass (Vetiveria zizanoides), Chenopodium species, and grain and leaf Amaranths.
- * Tree species and shrubs of value in agroforestry and alley farming practices and in restoring the fertility of degraded and waste lands.
- * Plant species of value in veterinary and human medicine.

Such a specialised genetic garden for sustainable agriculture is currently being established at Madras. In addition to such specialised genetic gardens, we also need genetic enhancement centres where novel genetic combinations can be

developed for distribution among field-level plant and animal breeders. ICGEB in association with IBPGR and other IARC's could develop a global grid of specialized genetic resources and enhancement centres.

There is also need for national, regional and global efforts in promoting basic research on topics of relevance to the application of biotechnology. The Rice Genome Research Advisory Committee, organised by Japanese scientists, is a good example of the kind of initiative which ICGEB and IARCs should foster.

3.2 Dissemination of information and awareness generation

In the area of dissemination of research results, several mechanisms already exist, as indicated earlier. Nevertheless, there is need for special information centres at the regional level for giving credible information to financial institutions on the cost, risk and return aspects of new biotechnological innovations. UNIDO can help to establish such a network in collaboration with FAO, UNESCO, UNEP, WHO and UNCTC, as well as the Economic Commissions for Africa, Latin America and the Caribbean and Western and Southern Asia. Such Regional Information Centres for the commercialization of biotechnology should have a network of sources of credible information.

Another area where there is need for public awareness and action is the protection of habitats rich in biological diversity. The pressure of population as well as some of the pathways of development chosen have resulted in a gradual destruction of major ecosystems like hill, wetland and coastal ecosystems and to the loss of habitats rich in fauna and flora. Because of the diversity of soil, climate and growing conditions, India is rich in its endowments of plant species. Habitat destruction and the extension of agriculture to forest areas promote species extinction. But for the green revolution, more forest land would have got diverted for the cultivation of annual crops. For example, India produced 12 million tonnes of wheat from 14 million hectares in 1964. In 1990, 55 million tonnes of wheat were produced from 24 million ha. Hereafter, the additional food requirements will have to come from higher productivity per crop and higher intensity of cropping. Higher yield has to come from higher biomass production and better harvest index. Such progress will be possible only with the help of biotechnology.

help of the tools of molecular biology and biotechnology would suffice to convey a sense of hope and optimism in relation to the potential for improving the quality of life for humankind during the remaining years of this century. It is equally obvious that biotechnology is one area of research that has attracted widespread interest among both private industry and the academic world. The implications of modern biotechnology research for human welfare are far-reaching. The very power of the new tools of genetic engineering make the adoption of codes of ethics and safety imperative. Earlier in this paper methods of imparting a pro-poor bias in the choice of research problems have been described. Biotechnology also helps to increase the carrying capacity of supporting ecosystems through new opportunities for employment generated by the efficient use of biomass and by higher crop and animal productivity.

The time is opportune for organising a CG-Biotech to serve as a global coalition for the application of biotechnology for sustainable development. Such a global coalition of private and public sector industry, foundations, academic institutions, government agencies and international research institutions/ organizations can help to stimulate, support and spread environmentally friendly biotechnologies worldwide. It can promote the blending of traditional and frontier biological technologies.

3.5 Structure of CG-Biotech

A few suggestions on how to structure the proposed CG-Biotech are given below:

Members: The following could provide the initial membership:

- a. Interested UN agencies and other international institutions
- b. Interested bilateral and multilateral donors, including IFAD and Regional Development Banks
- c. Foundations
- d. Representatives of private and public sector industry
- e. International Council of Scientific Unions and Science Academies
- f. Representatives of Governments representing the different regions according to the formula generally adopted in the United Nations.

Members of the CG-Biotech will meet annually to review progress and accelerate the dissemination of ecologically desirable technologies.

Co-sponsors: The CG-Biotech could be co-sponsored by UNIDO, FAO, UNESCO, IBRD, UNDP, UNEP and IFAD.

Secretariat: UNIDO could provide the secretariat for the Scientific and Technical Advisory Committee for CG-Biotech, since UNIDO is already servicing the Panel of Scientific Advisors for ICGEB.

Fiduciary agent: UNDP could serve as the fiduciary agent, as it has a global network of offices and programmes.

Scientific and Technical Advisory Committee (STAC): A multi-disciplinary STAC with a widely respected biotechnologist as chairman should be established to assist the CG-Biotech in choosing priorities and in making investment decisions. STAC should pay particular attention to the development and dissemination of "green" or environmentally benign biotechnologies in agriculture, industry and medicine. It should also advise CG-Biotech on the following issues:

- a. Biosafety
- b. Wholesomeness
- c. Intellectual property rights
- d. Biological diversity and biotechnology
- e. Bioremediation
- f. Human resource development
- g. Data base development and information exchange
- h. Recognition of informal innovations, and
- i. Ethical and equity issues

STAC could have about 15 members drawn from the academic world as well as industry, representing the spectrum of expertise essential for promoting a dynamic biotechnology industry in all parts of the world.

3.6 Method of operation

CG-Biotech could implement its mandate through mechanisms such as the following:

- a. Global and regional networks of existing private and public sector institutions, including appropriate CGIAR, FAO, UNESCO and WHO Networks.
- b. ICGEB and its global outreach centres.
- c. Individual national, regional and international research centres.
- d. Newly established centres of excellence.
- e. A global grid of genetic enhancement centres, and
- f. Information centres for commercialisation of new innovations.

The aim should be to optimise the benefits of existing centres and to fill critical gaps in on-going work, with particular reference to research areas of particular relevance to the economically and ecologically handicapped sections of the human population.

3.7 Extending the benefits of "green technologies"

New biological technologies are by and large "green" or environmentally friendly. A priority item on the agenda of CG-Biotech should be extending the benefits of the new technologies already on the shelf among developing countries. The following areas need particular attention:

- a. Improving the productivity, profitability, stability and sustainability of major farming systems.
- b. Enlarging biomass-based energy production on the lines of the work already underway in EC countries, under the Large European

Bio-energy Network (LEBEN) programme and promoting ecologic bioprocessing.

- c. Combating desertification through the rapid spread of suitable leguminous and other tree species, using mist and micro-propagation techniques.
- d. Spreading the benefits of new developments in improving human and animal health.
- e. Control of pollution including the use of micro-organisms through bioremediation techniques.

The above activities can be packaged in a "biovillage" module form, as described in detail in the book "Biotechnology in Agriculture" (see Swaminathan, 1991). The establishment of pilot biovillage projects to achieve the triple goals of higher productivity, income and employment opportunities should be accorded priority. For this purpose the CG-Biotech could establish a Biovillage Science and Technology Coalition consisting of industry, research and training institutions, institutional credit agencies, representatives of women's and social science organizations and representatives of mass media. Such a coalition in collaboration with appropriate government and non-governmental agencies can foster the growth of biovillages in all parts of the world, based on the principle of integrating the best in modern biological technologies with the best in traditional wisdom and technology.

3.8 Conclusion

The establishment of a CG-Biotech for Sustainable Development is an idea whose time has come. If implemented, this will be one of the most significant contributions in the area of promoting the quality of human life within the limits of the carrying capacity of the supporting ecosystems. The experience gained from the operation of the CGIAR during the last 20 years indicates that a flexible dynamic system of organization coupled with effective mechanisms for priority setting, policy oversight, extension and monitoring will help to generate the confidence of both donors and developing countries. It would hence be

appropriate to organise soon a "Bellagio-type" conference to develop this idea further and make it into an operational entity. UNIDO could take the lead in organising such a Bellagio conference on the establishment of a CG-Biotech.

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ECG	-	Electrocardiogram
ECU	-	European Currency Unit
EDF	-	Environmental Defence Fund
FAO	-	Food and Agriculture Organization of the United Nations
GATT	-	General Agreement on Tariffs and Trade
GAW	-	Global Atmospheric Watch
GMO	-	Genetically modified organism
HDI	-	Human Development Index
HRP	-	Special Programme of Research Development and Research Training in Human Reproduction
IAEA	-	International Atomic Energy Agency
IARC	-	International Agricultural Research Centres
IBPGR	-	International Board for Plant Genetic Resources
IBRD	-	International Bank for Reconstruction and Development
ICARDA	-	International Centre for Agricultural Research in the Dry Areas
ICGEB	-	International Centre for Genetic Engineering and Biotechnology
ICRISAT	-	International Crops Research Institute for the Semi-Arid Tropics
ICSU	-	International Council of Scientific Unions
IDB	-	Inter-American Development Bank
IFAD	-	International Fund for Agricultural Development
IITA	-	International Institute for Tropical Agriculture
ILO	-	International Labour Organisation
ILRAD	-	International Laboratory for Research in Animal Diseases
IPR	-	Intellectual property rights

IRRI	-	International Rice Research Institute
ISNAR	-	International Service for National Agricultural Research
IUCN	-	International Union for the Conservation of Nature
LEBEN	-	Large European Bio-Energy Network
MIRCEN	-	Microbial Resource Centres
NARS	-	National agricultural research systems
NEST	-	New and emerging science and technology
NGO	-	Non-governmental organization
NIMBY	-	Not in my back yard
OECD	-	Organization for Economic Co-operation and Development
PBR	-	Plant breeders' rights
PGR	-	Plant genetic resources
PSA	-	Panel of Scientific Advisors
RFLP	-	Restricted fragment length polymorphism
SAGB	-	Senior Advisory Group on Biotechnology
SAARC	-	South Asian Association for Regional Cooperation
STAC	-	Scientific and Technical Advisory Committee
TDR	-	Special Programme for Research and Training in Tropical Diseases
TMV	-	Tobacco mosaic virus
TNF	-	Tumour necrosis factor
TRIPS	-	Trade-related Intellectual Property Rights
UNCED	-	United Nations Conference on Environment and Development
UNCTAD	-	United Nations Conference on Trade and Development
UNCTC	-	United Nations Centre on Transnational Corporations
UNDP	-	United Nations Development Programme

- UNESCO - United Nations Educational, Scientific and Cultural Organization
- UNEP - United Nations Environment Programme
- UNIDO - United Nations Industrial Development Organization
- UNU - United Nations University
- UPOV - International Union for the Protection of New Varieties of Plants
- WCED - World Commission on Environment and Development
- WHO - World Health Organization
- WIDER - World Institute for Development Economics Research
- WIPO - World Intellectual Property Organization
- WMO - World Meteorological Organization
- WWF - World Wildlife Fund
- YAC - Yeast artificial chromosome

