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Management of Change in All India Coordinated Crop Improvement Projects

DIRECTORATE OF RICE RESEARCH

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Group Discussion

February 24-26, 1992

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Group Discussion, February 24-26, 1992

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All India Coordinated Crop Improvement Projects : Organization and Management

R.S. Paroda

Indian Council of Agricultural Research, New Delhi

The agricultural scenario all over the world is undergoing a rapid change. From subsistence farming, agriculture has tended to become an occupation, industry or business. Advances in agricultural technology have invariably contributed to increased production. Agriculture has been and will remain the most crucial factor in the economy of developing countries. The need for a dynamic agricultural research and educational system is vital.

Heralding and sustaining the 'Green Revolution' in India have obviously been a reflection of sound agricultural policy planning aimed at rapid growth and increased production of food grains. Over the last four decades, Indian agriculture has witnessed spectacular advances in both production and productivity through the dedicated efforts of farmers, researchers and planners, coupled with necessary administrative and political support. Food grain production rose from 50 mt in 1950-51 to a record 172 mt in 1988-89. During this period, rice production increased three-fold, wheat-eight-fold, sorghum two-fold, and maize three-fold (Table 1). All these crop commodities received the desired technological support from the coordinated crop improvement projects initiated by ICAR in late fifties or early sixties. Today, ICAR is funding 18 such projects at the national level, covering most of the economically important crops (Table 2). Presently, ICAR funds a total of 78 coordinated projects covering the disciplines of crop sciences, plant protection, horticulture, agronomy and soils, engineering, animal sciences, fisheries, etc. These projects have been conceived to focus attention on major national/regional problems by involving available scientific manpower at different institutions, so that the suitable answers are found through their joint but complementary efforts. The projects help

Table 1. Production of principal crops and livestock products in India

Crop	Production	
	1950-51 (mt)	1986-87 (mt)
Rice	20.6	60.4
Wheat	6.5	45.5
Sorghum	5.5	8.9
Maize	1.7	7.4
Total cereals	42.4	132.3
Chickpea (gram)	3.6	4.4
Pigeonpea (arhar)	1.7	2.3
Total pulses	8.4	11.7
Total foodgrains	50.8	144.0
Groundnut	3.5	6.0
Mustard	0.8	2.6
Total oilseeds	5.2	11.4
Cotton (m bales - 170 kg)	3.0 *	7.0
Sugarcane	57.0	182.4
Potato	1.7	12.7
Jute (m bales - 180 kg)	3.3 *	7.3
Milk	17.0	44.5
Eggs(m)	1,032.0 **	16,518.0
Fish	0.8	2.9

* m bales; ** million number

Table 2. Details regarding All-India Coordinated Crop Improvement Projects

Crop	Year of start	No. of centres	Staff strength		Budget (VII plan 1985-90) Million Rs.
			Scientific	Technical	
Rice*	1965	52	264	149	45.1
Wheat*	1965	32	162	122	45.0
Maize	1957	27	72	221	38.6
Sorghum	1969	16	59	81	22.6
Pearl millet	1974	10	40	73	17.4
Small millets	1984	8	39	17	7.3
Barley	1967	7	16	29	7.0
Pulses*	1974	34	375	194	96.7
Oilseeds* (including groundnut)	1967	63	332	405	103.0
Soybean	1967	14	59	54	44.0
Forage crops	1970	17	40	80	24.2
Cluster bean	1986	6	16	7	4.6
Under utilized plants		15	22	21	2.3
Tobacco	1970	11	27	23	9.3
Sugarcane	1970	22	38	44	14.9
Sugarbeet	1970	6	14	12	3.7
Cotton	1967	31	114	98	29.5
Jute and allied fibres	1967	9	61	29	10.4

*Projects now elevated to the level of Directorate; Currency rate-Rs.26=US $ 1

in joint programme planning, interdisciplinary and also interinstitutional interactions, and collective efforts in testing the technologies at several locations before their release to farmers. The collective process helps in defining the goals and objectives clearly in view of the priority of the problems, and the process defines the most relevant approaches for experimentation. The projects also help in effective accountability monitoring of different centres.

Although every programme has its strengths and weaknesses, the nationally coordinated crop improvement programmes in India have had a success story to reveal. The major benefits include: identification of national/regional problems; well proven technology recommendations; greater sense of participation; building of scientific capabilities; healthy competition among scientists; development of cooperative team spirit; complementarity of human and material resources available in the country and establishment of linkages at national and international levels.

Obviously, AICCIPs provides a model that could be replicated elsewhere suitable modifications. Various components of AICCIPs, such as concept and objectives, guiding principles, mandate, organizational and management aspects, merits and demerits, etc. are discussed to understand their implications clearly.

Concept

To coordinate research for dealing with important national problems.

Objective

To develop appropriate, well-tested technologies suited for increased production in different agroclimatic conditions.

Guiding principles

Problem must have national/regional perspective aiming at increased production; sharing of information and research material to be the guiding factor; joint planning and evaluation/testing of the technical program; providing inter-disciplinary and interinstitutional linkages; and strong national commitment and support.

Mandate

To plan and conduct multilocational testing at the national level, in order to generate appropriate varietal and management technologies for different ecosystems; to coordinate and monitor research networks relating to problems of national and regional importance; to conduct strategic and applied research for generating appropriate crop improvement, production and protection technologies by adopting an interdisciplinary research approach; and to function as a major programme for exchange of research material (including germplasm) and information.

Funding mechanism

The ICAR organizes funding of projects which have different centres located either at 27 State Agricultural Universities (SAUs) or at ICAR institutes. The AICCIP consists of a coordinating centre and a number of centres located in different regions, depending on the importance of the crop. The coordinating centre headed by the Project Coordinator and assisted by a small group of scientists from different disciplines is located in one of the central institutes or in SAUs; appropriately based staff, both scientific and technical, is provided at different centres. Often major/lead centres are provided with an interdisciplinary team of scientists, whereas subverification centres are established with a small component of scientists representing either plant breeding or agronomy only depending on the need. For such centres, ICAR meets 75% while SAUs contribute the remaining budget. Initially the Council met 100 per cent of the funds for these projects but changed the policy to ensure a better sense of participation in these programs by the state governments. Once a project is sanctioned, funds (Table 2) are released directly to the concerned SAU or ICAR institutes by the Assistant Director General to the Project Coordinator. In the case of four projects that have the status of a directorate, funds are released directly by the Project Director concerned and not by ICAR.

Organizational structure

As the success of any AICCIPs depends on the organizational support, a functionally workable system has been developed to ensure the required linkages, accountability and efficiency (Fig.1). While the Director General of ICAR is the overall controlling authority, the Deputy Director General (Crop Sciences) provides effective and functional support to these programmes. For administrative, financial and technical matters, the Project Coordinator reports directly to the Deputy Director General (Crop Science). The Assistant Director General concerned helps in technical coordination for matters requiring ICARs' support, and he is

responsible for the timely release of funds to all centres.

The Project Coordinator is required to have a good working relationship with the Director of the Institute or the Vice-Chancellor of the SAU where the coordinating unit is located. Though coordinators are supposed to be functionally independent, problems are sometimes encountered when the coordinator concerned is not tactful in handling delicate issues, such as responsibility, authority and accountability.

The centres of the programme function quite independently under the control of a concerned Director of Institute or the Director of Research although their technical programme is finalized in the workshop, which is in addition to research activities main programme. Each centre-in-charge provides all data and relevant information periodically to the Project Coordinator for compilation and documentation of the project report. A direct link between the centre-in-charge and Project Coordinator for the exchange of information, avoiding bureaucratic channels, is the key to the success of the programme.

In some projects, positions of Principal Investigator (PI) in different disciplines have been provided to ensure technical support and coordination relating to specific disciplines in the programme. In others, senior scientists from project centres are identified based on their proven leadership to perform the functions of Principal Investigator on a voluntary basis. However, this is not a rigid requirement and variations do exist. Similarly, responsibility to act as Zonal Coordinator (ZC) is assigned to the concerned senior scientist in each zone to discharge the functions of Project Coordinator in the respective zone, based on the size and functions of such projects in each of the zones. Additional funds are provided to such centres for the increased responsibilities.

Managing the project

The success of AICCIP's in India largely depends on proper planning and execution of well defined functions and responsibilities, delineated to the extent that everyone knows what role he is to play and how the system is expected to work within the framework of its policies, guiding principles and the mandate. It is necessary at this stage to understand the procedural and functional aspects enumerated below, associated with the management of these projects.

Coordinator's role

The coordinator of the programme is the most important person in the whole orchestra. His success depends on ability to coordinate and lead. Obviously, he must be respected for his scientific achievements and undertake his job with a full sense of dedication and a will to serve others in order to achieve the desired results. The Project Coordinator is responsible for proper planning, coordination and monitoring of the programme. He has to organize annual workshops, compile and edit the data for preparation of annual reports, visit and monitor the functioning of centres, and be a spokesman for ICAR relating to all research and development matters concerning his crop. His unit has to serve as a reservoir of information on all related aspects of the project. Though the Project Coordinator has no direct administrative control over the centres, he has to act both as facilitator as well as an advisor and, in the process, must maintain good working relations with all concerned.

The Project Coordinators are appointed through an All India competition by the Agriculture Scientists Recruitment Board (ASRB) for a tenure of five years, renewable for the next term based on performance. Procedure, therefore, has a builtin mechanism for selection on the basis of excellence with possible continuation or change, based on performance. Performance is judged annually by the concerned Director of the Institution or the Director of Research/Vice-Chancellor of SAU and in ICAR by the Deputy Director General and the Director General.

A Project Coordinator must possess the following qualities: established scientific leadership; command a respect in the group; a commitment to serve; ability to extensive tour for monitoring; ability to converse effectively; a good organizer and an effective coordinator; and a capability for effective data processing, compilation, editing and presentation.

The functions of a Project Coordinator include: coordinating the technical activities of the centres; effectively monitoring the programme; organizing workshops annually; facilitating technical programme planning in the workshops; acting as a link between ICAR and institutions; preparing annual reports and present salient findings in the workshop; organizing support system activities (off-season nurseries, hot spots, germplasm exchange, quality evaluation, etc.) and providing information support at the national level.

Annual workshops

For each of the projects, annual workshops are organized at different university/institute campuses by inviting all scientists associated with the programme. The senior officials from ICAR often attend. Concerned senior scientists not directly involved in the project participate as special invitees, and ICAR meets their travel expenses. Their participation generally helps in formulating the technical programme. Also, the development officials from central and state departments of agriculture are invited. Similarly, national seed organizations and representatives of the seeds division of the Central Department of Agriculture attend the workshop to finalize the breeder seed production programmes to be taken up next season by the concerned breeders/institutions/organizations. At these workshops, the number of participants varies between 50 to 200 (except in wheat and rice between 300 to 400) participants.

The major advantages of holding these workshops annually include: a review of the progress; finalisation of the crop production and protection technology recommendations; identification of the most promising varieties for release and for on-farm testing; collective discussion and finalisation of the technical programme for the ensuing of year; an assessment of countries crop-production; providing scientific interaction as well as exposure; generating a sense of participation in programme planning and execution; and a realistic assessment of the functional and funding problems of the centres. Possible disadvantages that might arise include: expenditure on travel and arrangements; difficulty posed by the presence of a large group; substantial time spent in travel; and monitoring technical programme with seriousness. It has, however, become amply clear that annual workshops have their distinct utility in achieving the desired goal set for these coordinated programmes.

Technical programme of the workshop

The outcome of the workshop largely depends on the technical programme and

the effectiveness with which it has been implemented. Any laxity could lead to a waste of valuable time and resources. The technical programme provides enough time to review and discuss the progress, development efforts, breeder seed production efforts, recent technological advances, etc. Major recommendations based on multilocational testing over different years are also finalised, including the identification of superior varieties for release. Mid course corrections in the technical programme are also effected wherever necessary.

Data reporting and workshop's annual report

One of the coordinating unit's functions is to ensure proper data recording and reporting. After the technical programme is finalised in a workshop, the Project Coordinator has to ensure timely supply of seed material for different coordinated trials, arrange for the chemicals required for testing (such as weedicides, fungicides, insecticides, etc.), and also supply data books to different centres. Data books ensure proper uniformity in reporting the results, which are then compiled, examined and processed through the statistical unit of the coordinating cell. The report must have all auxiliary data in order to facilitate effective discussion in the workshop. A comparative table on performance of each centre with respect to conduct/non-conduct or success/failure of trials/ experiments, is also given in the report from the point of view of monitoring. Concerned PIs and the ZCs give their input in report writing. Annual reports are made available, at least ten days in advance, to each centre to enable them to critically examine the data before attending the workshop.

In addition, the Coordinator has to prepare and present his own report highlighting the major achievements of different disciplines and centres. This report is presented by him in the inaugural session of the workshop. Similarly, each PI or ZC also has to prepare a brief report based on progress in his discipline for presentation in the workshop.

Varietal/testing procedure

All India testing of promising breeding material (varieties, hybrids, composites, etc.) helps in identifying the most stable, high-yielding or superior genotypes suited for different agroclimatic conditions (Fig.2). In the process, varieties are identified and released, not only for the zones/regions where they have been bred, but also for other regions as well. This helps in complementing the efforts of relatively upcoming centres where the breeding programme is not strong enough to cater to the needs of the specific region. Also, common testing helps in avoiding any possible bias towards the promotion of a breeder's own varieties. In the process, only the best material get identified for release.

Normally, it takes a minimum of three to four years to identify a promising variety. Cooperating centres nominate their promising material either for the national screening nursery (NSN), if the number is large, or directly for the initial evaluation trial (IET). NSNs and IETs are conducted for one year, and material that show promise on the basis of either significant yield advantage or on the basis of better disease/pest resistance, drought tolerance, quality attributes, etc. are promoted to the next stage trial (either IET or Advanced Variety Trials (AVT)), as the case may be. No variety that is inferior in yield than the

best check gets promoted to AVT. Best entries are tested in AVT for two years (AVT I and AVT II). Simultaneously, agronomical data are generated on promising varieties and the reaction to disease and pests are recorded under hot-spot conditions as well as under epiphytotic conditions at selected centres where competent expertise is available. Also simultaneously, field data are generated through on-farm trials conducted either by the extension staff or by the scientists themselves. At the time of identification, breeder must provide basic seed sufficient to cover 10 ha for test stock seed production required for minikit/on-farm trials. Concerned breeder has to submit the variety identification proforma (see Annexure) to the Workshop along with all supplementary data and relevant information for consideration of the varity identification.

Project monitoring

The most important aspect AICCIP's is its effective monitoring. Hence, it is not only important that annual workshops are organized so that the progress of the previous year may be reviewed and the technical programme for the next year may be finalised, but the system should be devised in a manner to ensure builtin monitoring system for achieving the desired objectives. Various monitoring mechanisms are listed below:

Centre's report

Each centre is supposed to prepare an annual report relating to work done during the year and the same is required to be circulated in the workshop. The centre-in-charge is also given an opportunity in the technical programme review session to present the major findings of the group. This mechanism provides an objective assessment of the progress made by different centres.

Monitoring tours

Each Project Coordinator or PI is supposed to visit all or at least a large number of centres during the crop season in order to monitor the progress of the research work/trials. It is obvious that sufficient provision for travel funds is necessary to conduct these tours. Also keeping in view the urgency or importance of the problem, the Project Coordinator may constitute the joint monitoring teams from time to time to visit the stations/regions and submit a report for effecting corrective measures.

Activity milestones

While finalising the technical programme in the workshop, due emphasis is given to delineate precisely what job is to be accomplished by which of the centres and what input is expected from outside or from within the system. For each of the projects, centre-related activity milestones are finalised. Immediately after the workshop, all technical details related to the projects/centres are supplied by the PC or the PI concerned. Also a definite schedule is prepared for the submission of data sheets/information by the centres to the coordinating cell.

Headquarter monitoring

In addition to the efforts made for effective monitoring by the Coordinator/PI concerned, different national programme are also monitored at ICAR Headquarters by the DG/DDG and ADG concerned through the following means: Participation in workshop to obtain the required direct assessment of the efforts made by different

centres; Quinquennial review of each of the projects by team of senior experts; and Release of funds directly by the Council or the Project Director to the centres, based on demand and recommendations of the concerned Project Coordinator. Past performance, both technically and financially, is taken into consideration by the concerned ADG/PD while releasing the funds. This also helps in indirect monitoring of the centres.

Identification and release of varieties

Based on all available data, variety identification proforma (Annexure) are filled out and submitted by breeders during the workshop for consideration of the Variety Identification Committee. The Committee is constituted by ICAR, which is generally chaired by the DDG/ADG and includes some senior experts not directly connected with the project. The Project Coordinator acts as Member Secretary, whereas all PIs or ZCs are requested to attend in order to provide technical information as well as their own input.

Once a variety is identified by the workshop, the breeder sends the proposal for release and notification by the Central Variety Release Committee, which is a statutory body under the Department of Agriculture and Cooperation, Government of India, and the Deputy Director General (Crop Sciences) of ICAR chairs the Committee. All the Directors of Agriculture of different states, Directors of State Seed Certification Agencies, the Project Coordinator concerned and some representatives of the seed industry, as well as farmers, are also members of this Committee. Once a variety is released and simultaneously notified by the Committee, its certified seed production programme can be undertaken by either public or private seed organizations. No seed can be certified unless the variety is released and notified through this procedure. Obviously, the coordinating system is a powerful mechanism for ensuring the release and production of only well tested superior varieties for different agroclimatic conditions.

At the time of release, the breeder must make available basic seed to cover at least a 10ha area for multiplication as stock seed by the Central State Farmers Cooperation of India (SFCI), a government undertaking. The Department of Agriculture and Cooperation meets the production cost for this multiplication and the seed is thus used for minikit trials with a view to popularize as well as to test these new varieties in farmers' fields. Minikits are conducted by the concerned State Department of Agriculture and funding support is provided by the Central Government in order to ensure quick adoption of new varieties by the farmers. Simultaneously, the breeder is supposed to undertake breeder seed production of these varieties, for which required financial support is provided by the Council.

Interinstitutional and interdisciplinary collaboration

As indicated earlier, one of the guiding principles of these coordinated projects in the interdisciplinary and interinstitutional linkages. Joint efforts of breeders with pathologists, agronomists, nutritionists, entomologists, nematologists, physiologists, etc., have helped in developing multiple disease and pest-resistant varieties, varieties possessing drought tolerance, good quality traits, and also the appropriate production and protection requirements for achieving higher

production as well as sustainability. Excellent examples are the multiple disease resistant varieties of wheat, rice, sorghum, maize, etc. Interdisciplinary teams work very closely to tackle difficult problems. For example, for disease screening, plant pathologists artificially inoculate the breeding material as well as create epiphytotic conditions which help the breeders to develop disease resistant varieties. Similarly, for quality improvement, the biochemists screen the available genetic variability for desired traits. Agronomists work out appropriate production technology and so on.

Also, the coordinated programmes generate interinstitutional collaboration for resolving problems of national importance. Such interactions are often complementary in nature. Through these coordinated projects, effective linkages have also been established with international institutes, such as CYMMYT, IRRI, ICRISAT, CIAT, CIP, IBPGR, ICARDA, etc. A large number of breeding material, international trials/ nurseries and germplasm accessions are being exchanged and tested. In each workshop, it is decided which of the international trials/nurseries would be of interest to the programme and where these material are to be tested/supplied.

Such interactions have proved to be highly rewarding and mutually beneficial, both to the national programmes and the international centres. The best examples are of the dwarf high-yielding wheat and rice supplied by CIMMYT and IRRI. However, the coordinated programmes were instrumental in the testing and release of these varieties for the best suited agroclimatic conditions.

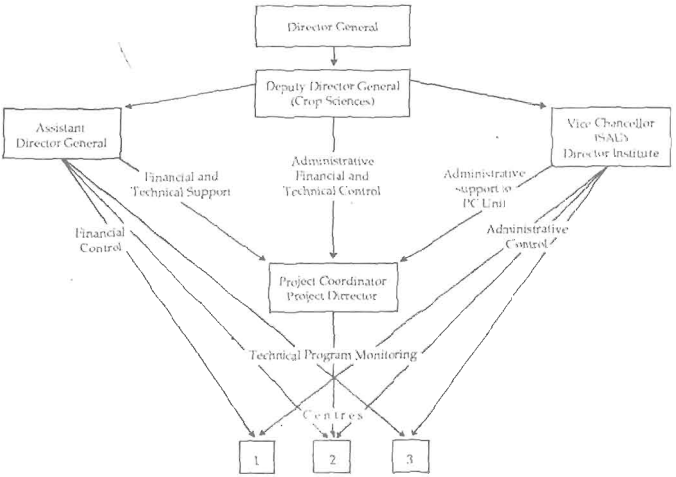

Fig. 1. Organizational Structurre of All India Coordinated Crop Improvement Project

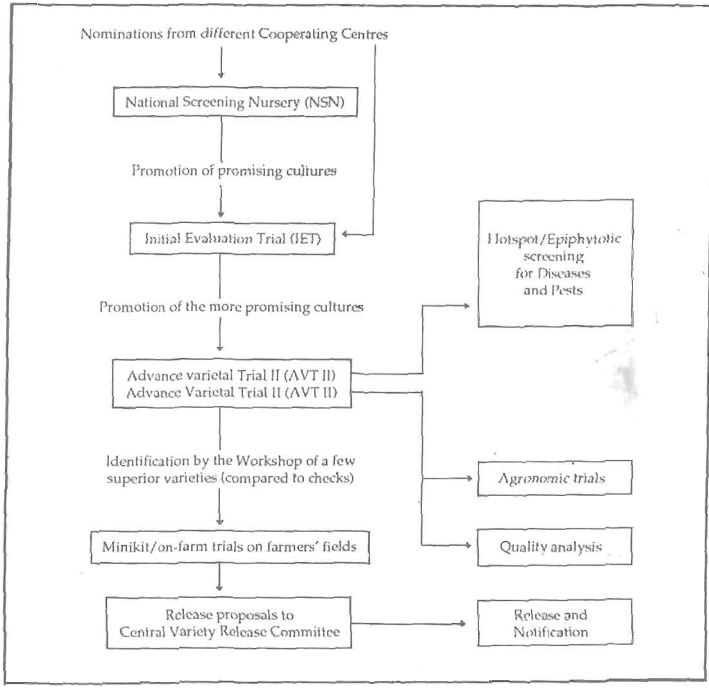

Fig.2 Procedure for varietal testing and release through coordinated projects

Annexure

Proforma for submission of proposal for identification of crop varieties/hybrids by the All-India Workshop

1. (a) Name of the variety/hybrid : ----------

   (b) Species : ----------

2. Perantage : ----------

3. Breeding method used : ----------

4. Developed by (Station and names of workers) : ----------

5. Proposed by : ----------

6. Zone for which to be identified : ----------

7 Production condition for which to be identified : ----------

8 In case of hybrid, description of the parents : ----------

9 List at least two important morphologicial features of the proposed variety/hybrid which distinguish it from other important commercial varieties under field condition. Also enclose seperately a complete description of the variety* ----------

10. The new variety/hybrid provides an alternative/ replacement for : ----------

11 List main problems and special requirements (in order of importance) of the concerned area of recommendation and how the proposed variety helps to resolve these ----------

12. Year when first entered in Coordinated Varietal Trials: ----------

Quantity of breeder seed available
(a) Variety: ----------

(b) Parental lines in case of hybrids: ----------

14. Summary data as per enclosures Tables 1,2,3,4 and 5 plus appendices: ----------

15. Problems and prospectus in seed production of parental lines and hybrids and their maintenance (wherever applicable). ----------

* For complete description of the variety/hybrid/parental lines. Use the list of descriptors approved by the project/workshop

Table 1: Summary yield data of coordinated varietal trials

Name of proposed variety/hybrid : ---------- Adaptability Zone : ----------

Production condition: ----------

	Year of Testing	No.of trials	Proposed variety	Check Var.1	Check Var.2	Check Var.3	Qual. Var.1	Qual. Var.2	Qual. Var.3	CD
Mean yield (kg/ha)	First year									
(a) Zonal	Second year									
(b) Across zones (if applicable)	Third year									
	MEAN									
Percentage increase or decrease over the checks and qualifying varieties	First year									
	Second year									
	Third year									
Frequency in the top group (pooled for 3 years)										

Note: Qualifying varieties is one which has completed three years of testing in coordinated trials; Centre-wise and year-wise data must be appended with this proposal. The actual names of varieties/hybrids must be written in various columns provided in the place of proposed variety, all the check varieties (including the latest identified variety) and all other varieties (which have completed three years of coordinated testing) should be given. Zonal mean yield or across zonal mean for those varieties proposed for more than one zone for each of the three years are to be given along with the relevant CD in the first three rows of the table. In the next three rows, the percentage increase or decrease in yield for the proposed variety as compared to each of the listed varieties are to be given. If the proposed variety yield is more than that of the variety with which it is compared, put a + sign and if the yield of the proposed variety is lesser, then put a-sign before the percentage value. Note that in the absence of a *mark, the two varieties compared are supposed to be statistically at par. Only in rare cases, where the yield of the proposed variety is exactly equal to the yield of the variety with which it is compared, the sign before the percentage value will be '=' instead of '+' or '-', and the percentage value will be '0'. The entry in that case will be '=0'. In the last row of table 1, the frequency of appearing in the top group summed up for all locations over the three years is to be given along with the total number of trials, separated by a sign '/'. For example, if in three years of testing (including IET), a particular variety has been tested in 14 trials and if the variety has appeared in the top group in 10 trials out of these, then the entry for that variety will be 10/14.

Table 2 : Adaptability to changes in agronomic conditions

Name of the proposed variety/hybrid : ---------- Adaptation zone : ----------

Production conditions : ----------

	Item	Prop. var	Check 1	Check 2	Check 3	Qual.Var.1	Qual.Var.2	Qual.Var.3
Sowing date of experiments	Yield (kg/ha) under recommended sowing date							
	Percentage gain or loss when sown	Early						
		Normal						
		Late						
Fertilizer experiments	Yield (kg/ha) under recommended dose							
	Percentage gain or loss when under other doses	F0						
		F1						
		F2						
Irrigation experiments (wherever applicable)	Yield (kg/ha) with adequate irrigation	Adequate						
	Percentage gain of loss with:	Irrigation Level 1						
		Irrigation Level 2						
		Irrigation Level 3						

Note: In each of the three types of experiments namely sowing dates x varieties, fertilizer x varieties and irrigation levels x varieties, the first row is meant for the actual yield of the variety in these experiments under the agronomic condition for which it is proposed. The rows below this are meant for percentage grain (+) or loss (-) shown by the variety when grown under the changed agronomic conditions. Here all rows are not necessarily to be used. For example, in the case of sowing date experiments, for a variety which is meant for late sowing, the percentage gain of loss observed at normal sowing only will be given, since a late sown variety is not likely to be sown by the cultivators earlier than the normal sowing. So, the row concerning early sowing will not be used in that case. For fertilizer experiments, in the case of a variety proposed for rainfed conditions, the percentage gain or loss with the fertilizer levels F0 and F1 will be filled up,while the row for F2 will be left blank, since for rainfed trials only three doses of fertilizers F0, F1 and F2 are tried of which F2 is the recommended dose for a rainfed condition.

Table 3: Reaction to major diseases

Name of the proposed variety/hybrid: ---------- Adaptation zone: ----------

Production condition: ----------

Disease	Item	Year	Prop. Var.	Check Var.1	Check Var.2	Check Var.3	Qual. Var.1	Qual. Var.2	Qual. Var.3
Artificial (1)		1st 2nd 3rd							
Natural (1)		1st 2nd 3rd							
Artificial (2)		1st 2nd 3rd							
Natural (2)		1st 2nd 3rd							
Artificial (3)		1st 2nd 3rd							
Natural (3)		1st 2nd 3rd							

Note: In each year, under natural conditions and artificial infection, the average coefficients of the infection are to be given along with the maximum intensity observed. For diseases for which coefficients of infection is not presented, the maximum disease/insect score in each year may be presented.

Table 4: Reaction to insect pests

Name of the proposed variety/hybrid: ---------- Adaptation zone: ----------

Production condition: ----------

Disease	Item	Year	Prop. Var.	Check Var.1	Check Var.2	Check Var.3	Qual. Var.1	Qual. Var.2	Qual. Var.3
Artificial (1)		1st							
		2nd							
		3rd							
Natural (1)		1st							
		2nd							
		3rd							
Artificial (2)		1st							
		2nd							
		3rd							
Natural (2)		1st							
		2nd							
		3rd							
Artificial (3)		1st							
		2nd							
		3rd							
Natural (3)		1st							
		2nd							
		3rd							

Table 5: Data on quality characteristics

Quality Characteristics	Years	Proposed variety	Check Var.1	Check Var.2	Check Var.3	Qual. Var.1	Qual. Var.2	Qual. Var.3
Parameter 1								
	Mean							
Parameter 2								
	Mean							
Paremeter 3								
	Mean							
Paremeter 4								
	Mean							

Name the parameter

Conduct of Workshops

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The team 'Workshop'in its present usage became a common addition to the vacublury of the agricultural scientists in India with the introduction of the first workshop by the All India Coordinated Crop Improvement Project (AICCIP) on maize crop in 1957. Prior to that the workshop was generally understood to mean only 'a room or building where work is done'. In the present context according to the 'Webster's New World Dictionery of American language it also means a group of people who meet for a period of intensive study, work etc in some field.

When the ICAR introduced AICCIPs this unique feature of organizing workshops, where cooperating scientists and others participated, was introduced. The basic feature of these projects was the multidisciplinary approach to tackle the problem of the crop improvement by scientists located in the ICAR Institute, State Agricultural Universities (SAUs) as also other institutes engaged in agricultural research. Therefore, it is imperative to bring together a group of scientists periodically, generally annually, in a workshop. The aims of such workshops include: to review the work done during the previous year; to chalk out details of trials to be conducted during the ensuing year; to identify varieties for testing at the farmers' fields as also for general cultivation in the various zones; and to take stock of the operational difficulties and to devise means to remove them.

The workshops are generally organized according to the following programme: Registration; Inaugural Session; Technical Session; presentation of results and discussion, breeder seed production, presentation of special topics, discipline-wise review of ongoing research and formulation of centre-wise technical programme of work, and Plenary Session.

Major thrust of the workshops is the presentation of results of the experiments conducted by the scientists of various disciplines working at different research centres/Sub-centres/Cooperative centres, discussions thereon and on priorities, approaches and planning of research work for the coming year. Breeder seed production programme of various varieties is planned keeping in view the indents, quantum of seed produced and quantum of seed lifted during the previous year. Discipline-wise meetings are held to discuss the experimental results and plan the future work. The research programmes thus formulated are presented in the plenary session for each discipline, where the work plan decided in discipline-wise meetings is once again discussed and finalised. Personel from the state departments of agriculture and other agencies involved in both development work and extension of improved technology are also invited to give their views on the response of farmers and the problems faced (by the staff and farmers) in the adoption of new technology. Presentation of lectures on current research

topics by eminent scientists is not a regular feature in all the workshops but depends more on the initiative and interest of the project directors/coordinators. A subcommittee meets to discuss the proposals for the identification of the varieties for release. The workshop comes to a close after the remarks of the Chairman of the Plenary Session.

The workshop no doubt serve a very useful purpose of discussing results, formulating the technical programme for further experimentation and for an interaction among different scientists, disciplines and centres working on a crop or project. However, a feeling is emerging that the workshops are now taking the form of ritualistic gettogether. There is a scope of improving their conduct qualitatively so that apart from stereo type work, new ideas emerge which are useful for research and all round improvement of a project. The present paper is being presented in this background with a view to suggest some improvements.

Planning of workshop

The planning for holding the workshop in terms of the data and venue should be made well in advance so that the scientists working at far off stations get enough time to plan their journeys. A clear notice of four to six weeks is essential. The venue of the workshop should be chosen keeping in view of its easy accessibility by rail/road. The facilities for boarding and lodging should also be considered in deciding the venue. Further, venue must be rotated in the different parts of the country. The relevant information including climate chosen venue, the history and places of interest should be appended with the circular announcing the venue.

Delay in holding the workshop adversely affects the quality of experimental data due to late planning and execution. The workshops must be held in time so that there is sufficient time for sending the seed to the coordinating units which have to formulate the trials and despatch the material to the various centres.

Types of workshop

In most crops, national workshop are held annually. In some cases zonal and national workshops are held in alternate years as in cotton. The zonal workshops are very important in cotton because of diverse needs of different regions in terms of varieties due to its photosensitivity and the lastly different dates of sowing. National workshops may be held twice a year for the scientists handling a group of crops, such as pulses and maize or even for single crop as maize which is grown in both kharif and rabi seasons.

This system has served well. However, national workshops have an advantage over zonal workshop as these facilitate greater exchange of ideas and germplasm. The national workshops should be preceded by zonal/subzonal monitoring of experiments and spot discussions. It may be mentioned that as a result of location specific research wide adaptation of varieties may not remain in vogue. This will necessitate strengthening of zonal meetings, workshops, discussions etc. in future. The workshops ought to be need based and the pattern may vary from crop to crop.

Participation

In the earlier years apart from the Project Coordinator the concerned Deputy

Director General almost invariably attended the workshops and for major crops even Director General participated. Similarly from SAUs Directors of Research and Heads of Departments gave the benefit of their experience. Such a level of participation seems to be on the decline. No doubt the number of projects has increased but there is also a marked increase in the scientific positions.

Generally the senior scientist of each discipline at various centres are invited. This needs to be broadened by inviting more than one scientist from a discipline, and scientists working in state sponsored projects. Participation of young scientists should also be encouraged. Further, sufficient funds should be provided to meet the expenses as it is a productive investment. It will be better if the incharges of AICCIPs at various centres are consulted about the scientists to be invited.

The workers involved in developmental activities are generally invited but their participation is almost always poor. It needs to be improved for better interaction between research and developmental staff.

The scientists who are not invited but attend the workshop face problems at the time of registration. Generally they are not provided with data books and other materials. They also do not get the proceedings. This can be obviated if invitation are extended in consultation with scientists incharge of different centres.

Duration and schedule of sessions

The duration generally varies from 2 to 5 days. The work has to be rushed through when the workshop is for 2 days, and 5 day duration being quite long results in loss of interest. It may be desirable to have 3 or may be 4 day workshop depending upon the importance and problems of the crop or group of crops.

The programme should be strictly followed. Many times, some sessions are delayed or extended at the cost of the subsequent sessions(s) which results in late night sittings or curtailing of an important session/discussion. Late night sittings are not condusive to rational discussions and these should be avoided. The chairman of the session should be briefed to finish the business in the allotted time.

Proper conduct of inaugural session offers golden opportunity to improve the performance of workshops. Normally this session is delayed and extended. The state of affairs can be tremendously improved if inaugural session is restricted to scientific and technical topics. This session needs to be made less ceremonial and more business like. The main purpose of the session should be to get organized.

Chair persons of technical sessions

Generally eminent scientists are asked to chair the technical sessions. Sometimes eminent scientists who are either not fully aware of the present position of the project or probably are not properly briefed by the Project Director/Coordinator/ other concerned scientists chair the session and mould the proceedings in accordance with their views which sometimes do not fit in fully into the on-going approach. The chairperson should preferably be an eminent scientist of the discipline who is conversant with the set up of the project. However, eminent scientists from other disciplines/projects must be invited for new ideas and promotion of interaction,

they may participate in scientific seminar proposed else where in this paper.

Identification of new varieties

Normally, the proposals are presented by the concerned scientist and discussed in the full house. Final decision is, however, taken by a sub-committee constituted especially for this purpose. The Project Coordinator and Principal Investigators are usually the members among others. This committee frequently sits late night which results in rushing through the agenda. This is a very important session. So, it should be planned in such a way that it is not a late night meeting. All the committee members should attend the full house discussion. Further, the sponsoring breeder should be asked to present the proposal before the sub-committee as many members of the sub-committee do not attended the full house session. The membership of the committee should include some scientists other than those from coordinating unit.

The limitations of the varieties which are not approved should be clearly stated and circulated for the benefit of the workers. This should greatly help in guiding the future plan of work.

The meeting of the sub-committee should invariably be held at the venue of the workshop and the decisions be arrived at the time of workshop.

Scientific interaction

Generally the scientists working in the coordinated projects are invited to attend the workshop. The eminent scientists working on a crop irrespective of the funding agency of their project should also be invited. The scientists who have made valuable basic research contributions should also be invited to deliver lectures under the provision of seminar on special topics. A few scientists from other crop projects may also be invited for interaction, discussion on policy matter and problems across crops and to generate fresh ideas. Interaction with developmental agencies of the centre and states is required to be strengthened during the workshops. A further interaction with international scientists should also be encouraged and invitations but sent to them well in time.

Seminar on special topics

At present the workshops are almost entirely devoted to routine of presentation of data and formulation of trials for the next session. Scientific topics, particularly related to basic research need to be identified and eminent scientists who have contributed in that area should be asked to present papers. Atleast half a day at each workshop may be devoted to such seminars. Even review papers on basic subjects will be useful. These seminars are expected to make workers conversent with the recent developments on the basic aspects besides breaking the monotony inculcating an interest. These topics and speaker should be identified at the previous workshop. In the reports presented by the centres a list of papers published during the year should be included.

Proper planning of experiments and timely reporting of data

For a meaningful conduct and for a practical discussion at workshop, availability of good quality data in time is a prerequisite. The experiments (treatments, experimental designs) should be thoroughly scrutinized and data reported. The project director/coordinator should in turn analyse the data, compile

and send the same to various scientists in time so that they come to the workshop after doing the home work, ready for discussions. The release proposals and other presentations should also be circulated in advance.

Promotion of entries

The norms (based on yield, disease, reaction, maturity etc.) for the promotion of entries from one stage to the next have been laid down for each crop. It is observed that sometimes these are very rigidly followed whereas in other instances, there is a too liberal approach. The former results in deletion of good genotypes and latter in enhancing the cost of experimentation. It is suggested that a realistic approach should be followed in the promotion of entries. Yield potential and other trials should be given due consideration depending upon their relative importance. Infact, multiple selection indices should be developed, based on which, the strains should be graded using computer facilities. This will allow the use of information on multiple triats and also make the system easier for researcher. Now a lot of time is wasted on the promotion of entries but still the data considered only for a few traits. Further, a selected group of scientists may be asked to meet for a day in advance of the workshop and discuss the promotion of entries. The promising entries so identified may be later got ratified by the general house of the workshop so as to involve collective thinking.

Projection of slides

It has been observed that the quality of slides and the size of the screens available in the halls is such that in some cases even the persons sitting in the front rows are not able to read the figures projected on the screen. The type of slides and screen used may be fit for a small class room but not for a big hall. The speakers is most cases use these slides as an aid for them to speak rather than as an aid for the audience. The minimum letter size should be visible at the maximum anticipated viewing distances from the screen/charts etc. For guidance such details are given in Table 1.

Table 1. Minimum letter sizes for maximum anticipated viewing distance

Maximum anticipated viewing distance	Minimum letter height (in mm)	
	Art work area: 17 x 22.5 cm	Art work area 22.5 x 30.5 cm
Projected aids		
4 W*	2.2	3.0
6 W	3.2	4.5
8 W	4.7	6.5
10 W	5.5	7.5
12 W	6.7	9.0
Non projected aids		
2.5		0.62
5.0		1.25
10.0		2.5
20.0		5.0

*Where 'W' is the width of the screen.

The speakers who intend to show slides should trial run them in a hall and make sure that even the audience at the back seats can read the data presented. The institutions hosting the workshop should select screen dimensions commensurating with the size of the hall. The ICAR will be well advised to get a paper prepared on this subject and circulate to all concerned for their guidance. This will improve the effectiveness of the data presentation through slides/charts etc.

Meaningful discussion

The importance of lively and meaningful discussions hardly need any emphasis. The level of discussions needs to be improved. The participants should be supplied with all relevant information beforehand. Enough time should be left for discussion and every effort should be made for sticking to the schedule. Young scientists should be encouraged to participate in the discussion. The senior scientists should also be specifically asked to actively participate in the discussion. Every effort should be made to promote serious participation and meaningful discussion.

Planning of India's Crop Improvement Programmes

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The earlier objective

India's Coordinated Crop Improvement Projects have received wide attention as a successful example of organizing agricultural research in a large country. These projects have influenced many developing countries in formulating their own crop improvement programmes on similar lines. Thus, some of the neighbouring countries of India including Pakistan and Bangladesh have established similar coordinated projects on their major crop commodities and countries like Kenya and Zimbabwe have attempted to introduce this model, with suitable modifications, in their national research system. ISNAR, which collaborates with the national agricultural research systems in helping them to improve their research policy, planning, organization and management has been taking the message of India's coordinated crop improvement projects to many developing countries. ISNAR in 1985 reproduced and widely distributed a paper which had been earlier published in India on the organization and management of these projects.

While reviewing India's own experience of these projects during the past 25 years, it is useful to recall that the coordinated projects as initially conceived and as implemented over the years were not imagined as an instrument for the planning of research programme on the different commodities at the national level. The projects, in my view, were modestly conceived and the main emphasis was on interinstitutional coordination of research activities, which in a country as large as India with two more or less independent streams of research, had to be carried out at a large number of stations - in the states and the central government institutes. The paper which I wrote in 1983 pointed out that the coordinator exercises little direct control over the the planning of research in the cooperating centres which, for all practical purposes, are guided by the policy of the institution in which they are located. The success of the projects has been largely a function of the interinstitutional and interdisciplinary collaboration which they have helped to foster. This collaboration helped to develop a nationwide varietal testing programme and procedures to identify new varieties and the associated production technologies for release to farmers. The emphasis has been on coordinated trials of varieties developed at different centers and on management practices associated with the new varieties.

I believe that the coordinated projects have been highly successful in achieving their major objective of harmonising research work at a large number of centres. The achievement of this objective alone would justify the continuation of the

coordinated projects. After all, it is much better that the scientists working at a large number of stations on common problems have an opportunity to meet and undertake some joint planning of the work to be carried out during the coming year, and review their findings, rather than have totally independent programmes. The planning part of it could be improved and some of us may not be fully satisfied with it and the costs may be high. However, none of these factors provide a good reason for abandoning the coordinated projects.

Transformation into national commodity programmes

The question we must now ask is: How can the All-India Coordinated Crop Improvement Projects (AICCIPs) be made more effective and more efficient? My answer to this question would be that AICCIPs should now be transformed into national commodity programmes. A national commodity programme is much more than a coordinated programme and presupposes a great deal of strategic planning. Strategic planning calls for a clear definition of national goals and objectives for the commodity for the next 10 years or so. It also calls for a transparent statement on the research strategy which would be followed to achieve these objectives with efficient use of the available resources. Although AICCIPs cover country's most of its important commodities, we have never clearly defined what our goals for each of these commodities are. We have assumed that the goal in each case is to increase production without asking questions about the relative position of a particular commodity in the national economy both for domestic use and for its export potential. We have rarely compared the different commodities with one another and we have seldom taken into consideration the notion of India's comparative advantage. Must we always talk of self sufficiency when it might be better to export one commodity and import another on the basis of an economic and agro-ecological analysis and our comparative advantage? Should we not be identifying regions where a particular commodity enjoys advantage for the best use of our natural resources and would best respond to research?

This whole question of planning and priority setting, and resource allocation for the different crop commodities needs to receive much greater attention than it does at present. We may be using a common sense approach in determining our research priorities and in deciding how much investment should be made in the case of rice research, for example, as opposed to research on maize or oilseeds. And again, we may be deciding what kind of research is most needed - more of plant breeding or more of agronomy? The common sense approach, of course, is useful but there really is no substitute for a detailed economic and agro-ecological analysis in taking important decisions of this kind. Our allocation of resources for research on different crop improvement programmes and different disciplines within these should have a well defined basis, and procedures for allocation of resources should be transparent and justifiable. What sort of analysis would be helpful?

Program planning and priority setting

Three levels of priority setting

The analysis which I propose above has to be institutionalized and a planning and monitoring group established in the ICAR to assist the policy makers in taking up this

responsibility. The process starts with the determination of broad national research priorities ranking the different commodities in relation to important national objectives. This kind of macrolevel determination of priorities for research obviously must involve the policy making level in the country including the Ministry of Agriculture, the Planning Ministry, and the Ministry of Finance, which provides the funds. For practical purposes, however, the Director General of ICAR, who is chief advisor to the government on agricultural research, must take the lead and must provide the planning secretariat to undertake the required analysis. It is the Director General, assisted by the planning group, who organizes the process of consultation with the concerned ministries and who finally decides on the broad national research priorities. The Director General should adopt some of the easily available methods of analysis which are now well known and which have been presented in a systematic manner by ISNAR in a number of its publications.

Once the ranking of the different commodities in terms of their relative importance in terms of the national objectives has been done and the resources allocated to each of these commodities by this policy making body, the next stage of the process moves to another group whose responsibility it is to help identify the opportunities and constraints for each of the different crops for research to make a significant contribution. What kind of research will have the largest pay-off and what kind of new technologies must be generated to be acceptable to farmers? One may argue that this kind of analysis of opportunities and constraints belongs to the scientists at the research stations and that they should normally undertake this exercise. The problem is that the scientist's own personal interest may not always coincide with those of policy makers, agricultural administrators, farmers and extension staff. Scientists, as we all know, can be academic in their approach. It is for this reason that for each of the major commodities, rice, wheat or maize for example, there should be a group of well informed senior scientists and extension staff who must do this kind of analysis. In the case of the Indian system, the national coordinator for a particular commodity is obviously well placed to take up this responsibility. It is the coordinator who must organize a small committee which is able to send clear signals to the scientists in the different agro-ecological regions with regard to the kind of experiments they should be planning, taking into consideration the identified constraints and opportunities. For example, if the main objective is to increase the production of oilseeds then the scientists must clearly be told to emphasize in their research soil and water management so that the adverse effects of dryland conditions on productivity are minimized. Several national research systems produce a document for each of their commodities listing the results of an exercise of this kind. These documents provide guidance to the scientists at the research stations for the formulation of their projects and experiments.

The third institutional mechanism for programme development involves setting of priorities at the project and the experiment level. This basically involves screening and approving the proposals prepared by the scientists at the research station. The important role of the research committee at the station must be recognized in this regard. The research committee examines the technical soundness of the proposed projects and makes sure that what

is being proposed is consistent with the analysis already carried out by the coordinator with the help of his own committee. This committee at the research station level must be multidisciplinary so that there is a complete coordination between the different disciplines at an experiment station.

Methodological framework

Quantitative analysis

So we have three different institutional structures which are charged with the responsibility of helping to define research priorities at the various levels. There is the Director General of ICAR and his planning group which, I believe is still to be organized from the existing resources of ICAR; there is the coordinator and his group of informed persons who would help to identify opportunities that constraints research should be addressing; and there is the research committee at the station level which determines which projects and experiments proposed by the scientists will be most consistent with the priorities identified by the two preceding groups. The question now is what kind of methodological framework can be given to these three groups to do their job objectively, systematically and with some well defined criteria in support of their decisions. Fortunately, a number of methods are available to assist in this process and these have been summarized in some of ISNAR's publications.

The method one chooses is really a function of the national development objectives and the research policies which follow from these. There is, for example, the domestic resource costs ratio; this particular kind of analysis is carried out when a country is most interested in being competitive on world markets. The method helps to focus research effort on commodities which have the best chance of competing in world markets and on research which will help to make it possible to substitute some of the imported products with those produced locally. There is the economic surplus method which helps to determine what will be the total benefit to the country from research and how these benefits will be divided between the producers and consumers. Who gets most benefit? In a country like India there is an obvious need to make sure that the interests of the producers are combined with those of the poor urban consumers. There is a limit to how much the government can subsidize the urban poor.

These methods involve a great deal of economic analysis and India is well equipped in terms of its enormous resources of highly trained economists to do an analysis of this kind. The more common approach which is followed in many countries is based on various scoring methods. The scoring methods begin by identifying what will be the objectives of research. These may be economic, social, political, scientific or a combination of all these. In general, three kinds of objectives are most commonly considered. First, there is the economic growth objective. Countries like India are obviously most interested in modernizing their agriculture and in making it an instrument of economic growth. This means that production, productivity and quality of the produce must receive major attention, and for this reason, a great deal of emphasis is placed on growth and production. The second national objective in many countries is related to social conditions, which means the distribution of benefits from research must be taken into consideration. Twenty five years ago the Government of India

decided to concentrate heavily on the irrigated, high fertility lands to increase production in the shortest possible time. The scientists were called upon to develop improved production technologies for the irrigated lands and much of the advance in our agricultural production is the result of this strategy of growth in the more favorable agroecological regions. Should this still be our major objectives today? There are concerns of a different kind: the equity considerations demand that millions of farmers in the dry and marginal lands also benefit from research. Secondly, there are major sustainability concerns and these cannot be addressed unless research priorities pay much greater attention to natural resource management. The third major objective, of course, relates to food security. The concern here is for stability of production, for approaches like disease and insect pest resistance, so that epidemics do not build up.

Scoring methods

These three major objectives are best taken into consideration with the help of a number of criteria which must be examined while setting priorities. Philip Parday at ISNAR has listed these criteria which shows that the three major objectives, growth, distribution of benefits of research and food security, can be assigned different weights depending on the policies of the government. The different commodities are then scored for the weight assigned to each of these objectives and in this way a ranking of the different commodities can be carried out.

The scoring of the commodities for the weight and objectives does call for a great deal of judgement on the part of the policy makers, agricultural administrators and the scientists themselves. But at least, we have a clearly enunciated method rather than someone allocating resources without any kind of structured analysis.

Philip Pardey has listed 41 different criteria under the three major objectives. For the growth objective, he suggested that we consider factors like value of production, potential for new land, probability of research successes, yield gap between the country and other countries and so on; for the equity goal we should be considering the number of people employed, number of producer, farm size, nutritional value, projection of family budget, share of commodity in urban consumption, important items consumed by the poor and so on. For the security goal, security of yield, productivity and production are important criteria: sustainable agriculture becomes another criterion. No one has suggested that the scoring methodology or any other method of priority setting should be used mechanically, they can be very useful, however, in making informed judgements.

National research plan

Finally, I should make the point that planning of commodity research programmes should really be an integral part of the process of strategic planning of national agricultural research, especially in countries where research is considered by the government to be an important instrument of development and of economic and social growth. It is expected that the national agricultural research system in India, with ICAR at its apex, would prepare a strategy and plan. The strategy should begin with a statement of national research policy and should move on to define the available financial resources, the institutional organization and structure, the national research priorities,

the research programme and the human and physical resources. The national plan could be built on the basis of the outline indicated below.

A. Statement of national agricultural research policy

B. Financial resources

(a) Analysis of past trends and future expectations

(b) Proposed mechanisms for generation of additional resources

(c) Sustainable budget for the next five to ten years

C. Institutional organization and structure including Linkage mechanisms and mandate of experiment stations.

D. National research priorities and resource allocation (macro level)

E. Research Programme

(a) Analysis of opportunities, problems and constraints which should help to define major research objectives.

(b) Definition of main research projects including allocation of scientific and other resources.

F. Human resource development plan including personnel policies

G. Physical resources

(a) Review of capital works and major farm and industry equipment

(b) Proposed rationalization, rehabilitation and identification of additional needs.

Management of Coordinated Crop Improvement Networks : An International Experience with Rice

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Networks serve as inexpensive, yet most effective, catalysts for research and provide an opportunity for isolated scientists to work together on common concerns. Working partnerships through structured collaboration, on the one hand, boost the efficiency in research efforts and, on the other hand, help to reduce the costs. Collaborative netwroks help to tap the spillover effects from regions where research is conducted to other regions with similar agroecologies. These benefits prompted the International Agricultural Research Centres to adopt the network approach in some of the major areas of research.

The International Rice Research Institute (IRRI) initiated organization and coordination of networks in the mid-seventies to foster cooperative efforts in selected areas of research. The International Network for Genetic Evaluation of Rice (INGER), formerly known as International Rice Testing Program (IRTP), is one such network established in 1975 in consultation with representative rice scientists from selected national programmes. The United Nations Development Programme (UNDP) has been providing funds for operating the network. Rice being grown in diverse ecologies and under diverse stresses in five continents, the network approach is considered very appropriate and effective in making available relevant genetic materials from different sources to various national programmes. Thus, IRRI, apart from disseminating the elite breeding lines generated by its own research, facilitates supply of best genetic materials originating from any other source through INGER to the various National Rice Research Systems.

Objectives of INGER

- To make the world's elite rice germplasm available to rice scientists around the world either for direct use or for use in crosses within their breeding programmes;
- To provide rice scientists with an opportunity to assess the performance of their own advanced breeding lines over a wide range of climatic, cultural, soil, and disease and insect conditions;
- To identify genetic sources of resistance/tolerance to major biotic and abiotic stresses;
- To monitor and evaluate the genetic variation (races, biotypes) of pathogens and insects;
- To serve as a centre for information exchange on the interaction of varietal characteristics with diverse rice growing environments in the world;

— To promote cooperation and interactions among rice improvement scientists in the world.

The programme thus represents an intercountry cooperative effort toward genetic improvement of rice targeted to the many environments in which the crop grows around the world.

With an access to a wide range of genetic materials and testing environments, economy of time is an important dividend for the network scientists in their efforts to develop improved varieties.

The network addresses the sustainability issue through a) promotion of genetic diversity to reduce vulnerability to pest epidemics, as accomplished by the exchange of a broader pool of genetic material, b) identification of wide range of genetic sources for durable resistance to diseases and insects that helps to minimize the use of expensive and hazardous chemicals; and c) identification of genotypes with stable yields under rainfed culture.

Participation in INGER

About 1,000 rice scientists from 75 countries in Asia, Africa, and Latin America and from the international centres (CIAT, IITA, IRRI, and WARDA) participate in the network. The trials are conducted at nearly 600 experimental stations belonging to either agricultural research institutes or to universities in the participating countries with a view to exchange, evaluate and identify elite rices adapted to different ecosystems, and resistant to different stresses. Scientists involved in the evaluation of the genetic material pooled by INGER include plant breeders, entomologists, pathologists, agronomists, soil scientists, and physiologists. Thus, the network forges strong linkages between the rice improvement programmes of the various national agricultural research systems, the ecosystem based research programs of IRRI, the IARC's with regional mandate for rice (CIAT, IITA, WARDA), and the International Rice Germplasm Centre.

Regional focus

The global network has three components, one each directed to serve the specific varietal needs of Asia, Africa, and Latin America. IRRI coordinates INGER at the global level, as well as its Asian component, whereas IRRI collaborates with IITA and WARDA in implementing the regional network in Africa, and with CIAT in respect of the regional network in Latin America.

Types of nurseries (trials)

Promising breeding lines/varieties originating from various national programmes and from the international centres are pooled together and organized into appropriate nurseries after multiplication and processing of seed. INGER nurseries fall under two broad categories: ecosystem oriented and stress-oriented. Under these two categories, a total of 30 different types of nurseries are organized each year and distributed to the participating countries based on location specific relevance and needs.

The ecosystem oriented category includes yield trials and observational nurseries. Separate sets of test material as relevant to different types of rice culture are composed for evaluation under irrigated, upland, rainfed lowland, deepwater, and tidal wetland ecosystems. The stress tolerance screening nurseries

have foucs on both biotic (major diseass and insects), and abiotic (temperature, moisture, and soil-related) stresses which may occur in one or more of the ecosystems.

Sources of entries

When the network was initiated in 1975, nearly 70% of the total number of test entries in different nurseries were from IRRI and the remaining from different national programmes. As of now, about 65% of the entries each year originate from the various national programs and 35% from the international centres, primarily IRRI. The increased contributions from the national programmes resulted on the one hand from their breeding researches gaining strength over the years and, on the other hand, from their realization of the benefits accruing from participation in a cooperative network. This has led to significant diversification of the genetic base of the exchanged material.

Rationalization of testing

Various measures have been taken from time to time to ensure that the network programme is both cost effective and that it is responsive to the needs of the national programmes as indicated below.

— INGER is regionalized on the basis of continents as a first step, to provide greater focus to region specific variety related problems.

— Within each country the ecosystems and stresses are prioritized and the participation is based on these priorities.

— To eliminate less useful material, the test entries where possible, are subjected to preliminary hot spot screening for different stresses at selected sites in different countries in collaboration with the concerned national programmes.

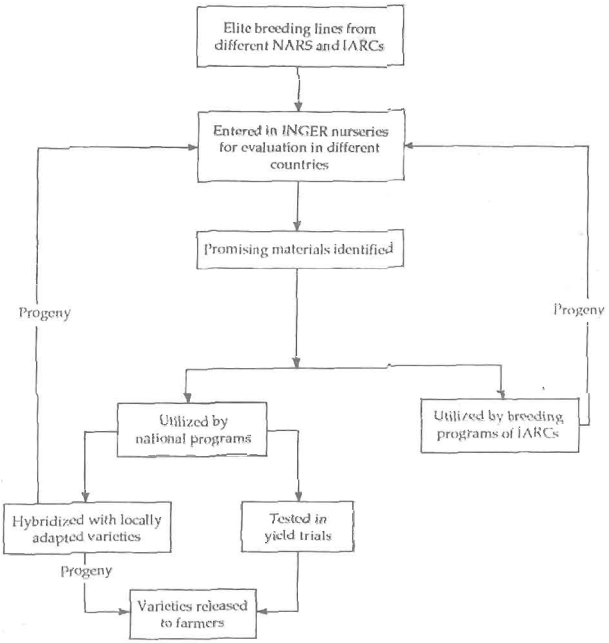
— Modules are set up within each nursery on the basis of growth duration, plant height, ecological adaptation or other relevant criteria, such that the participants can ask for the specific module of relevance to them instead of evaluating the whole nursery.

— When not many new entries are available for an ongoing nursery, it is discontinued until such time new entries are available.

— Greater emphasis is placed on observational nurseries as compared to the yield nurseries.

— For experimental stations with limited resources, selected promising lines based on available information are supplied, instead of regular nurseries.

The above mentioned steps ease the cooperating scientists from undue work load. Considering the number of countries participating in the network, and the diversity of production systems and stresses, INGER composes large number of nursery sets to match varying conditions. However, this does not affect the work load at individual sites. Approximately 40% of the test sites conduct only one trial each, 35% conduct two trials each, 20% conduct three trials each, and only 5% of the sites conduct more than three trials each. Needless to say, that some reasonable amount of time, money, and effort are involved in evaluating the nurseries, but these are more than offset by the resulting dividends.



INGER Flow Chart

Forums for interaction and planning

For successful realization of the objectives of the network, and in order for it to be responsive to the changing needs of the different countries, it is important that the participating scientists from different national programmes and the international centres interact periodically and exchange relevant ideas. The forums that stimulate such interaction among INGER participants are as follows:

— The INGER Advisory Committee consisting of representative scientists from national rice programmes, and concerned scientists from the IARCs as its members, meets annually to review the past results and formulate the future plans. Thus, the programme planning is done jointly by the network participants. INGER regional programmes are guided by regional steering committees.

— The International Rice Research Conferences organized by IRRI provide an opportunity to present and discuss results of specific INGER nurseries.

— Monitoring visits are organized annually for a joint review of INGER trials at selected sites in specific countries by a group of scientists from different national programmes and from IARCs. Such a review provides a useful feedback for followup trials, as well as for research strategies. Monitoring visits also serve as an important mechanism for training of participating young scientists.

— Correspondence, questionnaires, and newsletters also serve as important avenues for information exchange.

Seed managment

Two important aspects of seed management that receive attention of the coordination unit include maintenance of genetic purity for reliability of test results and maintenance of seed health to avoid transfer of diseases across countries, as well as, to retain seed vigor during the course of shipment and till the seeding time at different test sites. Seed processing facilities of the coordination unit at IRRI have been strengthened to meet these requirements.

Seeds of promising breeding lines nominated by different countries are sent to the coordination unit in small quantities one season in advance for multiplication and subsequent inclusion in specific nurseries. This will not only reduce the costs involved for the nominating countries in shipping large quantities of seeds required for network evaluation but also provide an opportunity for the coordination unit to check on the purity of the seed during multiplication. This also helps in timely processing of nursery dispatch since seed for all test entries is available on hand from the multiplication plots.

Both the incoming (entry nominations from different countries) and the outgoing (different seed sets composed as nurseries for evaluation) seeds are subjected to a series of physical and chemical treatments. The seed health unit of IRRI in collaboration with the Philippines plant quarantine agency ensures the effectiveness of these treatments through appropriate tests. Phytosanitary certificates accompany the nursery sets dispatched to different countries.

Data management

Specially designed computerized field books are supplied along with the seed to the network scientists. Observations and measurements as relevant to the individual nurseries are taken at different test sites by the concerned scienists and recorded in the field books. Each of the data sheets has three copies. One set of data sheets is sent to the coordinating unit at IRRI, one set to the national rice coordinator, and the remaining set is retained by the scientist conducting the trial.

Data received from different test sites are subjected to computer processing for storage and retrieval. Results of individual nurseries are analyzed appropriately and published twice each year (preliminary and final reports). Analysis of results is performed by location, country, region, and across all locations, and where appropriate, across years.

Multilocation data is gathered on both plant performance and site characteristics in order to study the genotype x environment interaction, understand plant responses to specific environmental attributes, and determine the levels and growth stages of tolerance to specific stresses. The data also provides opportunity to determine the key sites for different biotic and abiotic stresses.

To facilitate an uniform methodology in data collection, a monograph on (Standard Evaluation System for Rice) is made available to all scientists conducting INGER trials. Numerical scales and corresponding descriptors for evaluating various morphological, physiological, agronomical, and stress tolerance traits are summarized in the monograph. The scoring methodologies are jointly developed by the scientists from the national programmes and from IRRI.

Information dissemination

Reports on multilocation trial results, joint site visits, planning meetings, and other relevant information are published annually and distributed to rice scientists, research administrators, and libraries around the world. Information from these reports is utilized appropriately by different scientists and programmes in formulating followup research trials and strategies.

Salient research findings

The multilocation trials and screening tests in different ecosystems over different years led to some useful findings, and provided important research leads. Some examples are as follows:

- High-yielding varieties with a broad range of maturity and suited to different ecosystems have been identified.
- Varieties with moderately high-yield potential coupled with good degree of stability of yield performance have been identified for rainfed lowland conditions.
- Varietal differences were identified in respect of seed-related traits that have influence on field performance.
- Several alternate sources of resistance to individual stresses (diseases, insects, adverse soils, adverse temperatures, adverse moisture regimes) have been identified.
- Through differential reactions of varieties in multilocation screening tests, genetic variation (biotypes,

races) existing in major insects and pathogens that attack the rice crop has been established. Such information proved useful in designing location specific breeding programmes aimed at resistance to insects such as brown planthopper, whitebacked planthopper, and gall midge, and diseases such as blast and bacterial blight.

— Systematic trials at selected sites across the world provided information on the influence of major weather factors (temperature, solar radiation, etc.) on the expression of rice yields. The data proved helpful for simulation modelling and formulation of yield prediction equations.

— Identification of high-yielding, early maturing rices provided an opportunity for development of more productive cropping systems.

— Some lines were identified as fertility restorers in hybrid rice breeding programmes.

— Breeding lines that have potential for ratooning ability have been identified.

— Varietal differences were identified in their ability to retain seed vigor in adverse post-harvest environments.

Impact and accomplishments

● More than 200 test entries through INGER were released as varieties in 55 countries in Asia, Africa, and Latin America. These lines originated from the breeding programmes of 27 countries and from 3 IRRI, IITA, and CIAT. The released varieties include several examples of lines developed in one country having been named in another country, reflecting the international cooperation stimulated by INGER. But for their participation in the network, certain countries could not have exchanged and utilized genetic materials from each other's source due to political restrictions. Geographical distances proved no barrier in the usefulness and relevance of certain breeding lines across the continents. Some examples are: B 2161C-MR-57 from Indonesia was released as a variety in Cameroon; BG 374-1 from Sri Lanka was named in Brazil; PR 106 from India was released in Venezuela; P 901-22-11 from Colombia was named in Malaysia.

● Over 2,000 breeding lines/varieties distributed through INGER were utilized in various national breeding programmes as genetic donor parents for several important traits to improve the productivity of local varieties. For example:

- A test line, CR 61-7039-236 entered in IRTP nurseries by India was utilized as a parent in the local breeding programmes of Malaysia, resulting in the long grained, high-yielding variety MR 84, which is grown widely in that country.

- A traditional rice, Ptb 33 from India, entered in the IRTP nurseries was found promising against several diseases and insects in Sri Lanka. It was used as a parental line in the hybridization programmes of Sri Lanka, resulting in an improved variety with Ptb 33 traits, named BG 379-2. The latter, which was entered in IRTP nurseries was found promising in India, and was released as a variety under the name Adt 37.

- IR 46 from IRRI showed a stable performance in rainfed lowland trials. BR 4, a popular variety in Bangladesh, was improved through a cross with IR 46, resulting in a high-yielding line with good degree of stability, designated as BR 850-9-1-1.

- IRRI and the sister international centers concerned with rice have been making effective use of INGER's genetic assembly in their breeding programmes targeted to different ecosystems.

- INGER sponsored joint site visits and training programmes helped to enhance the professional capabilities of participating rice scientists from different countries.

- A strong and viable network established by INGER with a large body of committed rice scientists of different disciplines from across the world is an important achievement. The network has been serving as a powerful platform for international cooperation in addressing the continuous challenges in rice improvement for different ecosystems, through exchange, evaluation, and utilization of elite genetic materials.

Summary

In the process of harmony between rice and its environment, genetic improvement remains a continuing challenge, and for as long as genetic improvement efforts are in progress, there should be a mechanism for cooperative exchange and evaluation of those products. While the agroecological diversity of the rice crop poses a tough challenge for genetic improvement of the cultivars, the geographical diversity of the crop provides a valuable opportunity for cooperation among countries and research organizations. INGER precisely capitalizes on such opportunity. The individual strengths of national agricultural research systems may vary but their collective strength is considerable. The international cooperation through INGER meaningfully fuses the complementary strengths of NARS and the IARCs.

Zonalization vis-a-vis Varietal Evaluation

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Genotype environment interactions (g x e) are almost of universal occurrence in plant breeding experiments. When genotypes show differential behaviour across environmental spectrum the presence of g x e is indicated. When genotype x environment interactions are present the breeder has to make a choice between a single variety possessing general adaptation for whole range of environments or to breed varieties that show specific adaptation to subsets of environments which may be distinct zones or specified environments. In this context he has to also take a decision regarding the choice of environments for testing the varieties in respect of their adaptation to specified environmental conditions.

The environmental conditions may be classified in different ways. Comstock and Moll (1963) classified environments into two categories:

(a) Micro-environments which refer to the environment of single plants

(b) Macro-environments which represent general location effects in periods of time and are in fact a collection of micro-environments.

It is the (b) type environments which are of importance in the present context.

Allard and Bradshaw (1964) have classified environments into predictable and unpredictable types. The predictable types include some permanent features of the environments or fixed location effects like climate, soil type, day length etc. These also refer to controllable variables such as fertilizer dose, sowing dates, etc. as has been described by Perkins and Jinks (1971). The unpredictable environments, on the other hand, refer to seasonal fluctuations and hence include uncontrollable variables where precision of management is not attainable.

Type of variety vis-a-vis environments

Depending upon the type of environments, the choice of variety or its breeding will vary. For situations where g x e is mainly caused by uncontrollable variables the variety should show a low level of interactions so that it has a uniform performance across environments. Apparently, a variety having general adaptation is the choice which may attain this property through physiological buffering or developmental homeostasis (Verma et al. 1987).

When the g x e interactions mainly arise from controllable variables, a high level of interaction will be desirable to produce a maximum increase in performance. Thus breeding of varieties possessing specific adaptation will be desirable.

In terms of short-term and long-term environmental factors many decisions in plant breeding are formulated on the basis of predictable long-term requirements. According to Boyd et al. (1977) locations

within years are predictable under long-term requirements as well as for short-term requirements. The years within locations are unpredictable even under short-term requirements. While the final products of plant breeding endeavours are tested for long-term predictable conditions the segregating generations are tested for short-term predictable conditions. Subsequent selection, particularly for the characters with low heritability, therefore has to be based on unpredictable environmental variation in short-term. This requires evaluation of genotypes in replicated trials spread over environments.

Choice of environments for testing

The optimum environment for selection is that where there is greatest manifestation of genotypic differences and hence there is maximum progress from selection. There is a conflict in views regarding the type of test environment. Several studies have shown that favourable environment displays high genotypic variances and thus has more resolving power. However, other studies have shown that testing under low yielding environments is considered appropriate. The selections under good environments have been found to maximize the environmental sensitivities of high selections and minimize that for low selections (Jinks and Connolly 1975). Therefore, a positive correlation is generally found between high mean performance and high environmental sensitivity. Thus it becomes imperative to select under average conditions also for obtaining average sensitivities.

Frey (1964) performed selections under stress (low fertility and drought) and under non-stress environments and observed that selection under non-stress conditions retained most of the strains with wide adaptation.

It is clear that no single opinion holds good regarding the test environment and that the material needs to be tested under conditions in which they have to be ultimately grown. The early generation materials, in general, are tested at a single location and the resultant end products are tested over a wide range of environments. This procedure may cause erosion of certain genes. Thus simultaneous selections under stress and non-stress conditions have been suggested by Roy and Murty (1970). Verma and Kumar (1974) have suggested an integrated approach in which biparental crosses between selections under stress and non-stress conditions are made and the resultant progenies are grown under both situations. Borlaug (1965) suggested disruptive seasonal selection in wheat where the material is selected alternately under diverse environments so as to select for wide adaptation. This approach has been used in soybean to select lines with adaptation to spring, summer and fall seasons by Tsai et al (1970). In order to ensure wide adaptation, the segregating generations of wheat are alternately selected at Ludhiana and Gurdaspur by the Punjab Agricultural University.

Methods for identification of test environments

Various statistical procedures have been applied for the choice of optimal environment for evaluation as testing over locations and years is expensive in terms of time and money. By using these methods, environmental testing can be restricted to those environments which are most likely to provide maximum information or the test sites can be grouped into zones for

evaluation of varieties for release within and across zones.

Analysis of variance

The relative importance of components of g x e can be determined by analysis of variance technique from the interaction of genotypes with years and locations. It has been found that environmental effects associated with locations are most important in determining the g x e interactions followed by genotypes x locations x years effects for seed yield (Shorter et al. 1977).

Horner and Frey (1957) divided oat testing area of Iowa into subareas within which genotypes x locations interactions component was greatly reduced than the variance among lines. They also determined whether certain test sites contributed more than others to the line x locations mean squares. These methods help to define more uniform subregions within a region with regard to relative line performance and to identify those sites in which the line response is most dissimilar from that in all other sites.

Contribution of environments to g x e interactions

It will be useful to find the contribution of individual environments (or genotypes) to g x e interaction component. This is not possible in the analysis of variance technique but can be assessed by doing a pair-wise analysis of genotypes that estimates cultivar x location variance component for each cultivar and is called cultivar dependability (Plaisted and Patterson 1959). Same way a pair-wise analysis of locations has also been used to estimate the contribution of individual locations to g x e interaction (Shorter et al. 1977). In this analysis, locations are analysed in all possible pair-wise comparisons i.e. n (n-1)/2 pairs for n-locations. For each pair-wise analysis of variance the component σ^2_{gl} is estimated. Each environment will be involved in n-1 analyses of variance and hence there will be n-1 estimates of σ^2_{gl}. The arithmatic mean of these estimates for any environment represents the contribution of the environment to the total g x e interaction of the experiment. The environments that have largest mean σ^2_{gl} are important as test environments for breeding for wide adaptation whereas the environments with smallest contribution to σ^2_{gl} can be grouped in a zone.

Correlation between environments

Correlation between two environments using genotype means is often used as a general indication of the degree of similarity in response (Shorter et al. 1977). All possible pairs are computed and the correlation matrices so obtained represent repeatability of relative performance of lines at each location. A high correlation of any site with other sites is indicative of a high degree of repeatability of performance over other sites. This technique was used by Brennan and Byth (1979) in wheat. Any site showing poor correlation with all other sites has to be grouped in a different zone.

Falconer (1960) suggested the use of genetic correlations for selection of test sites. In this case different environments are regarded in the same way as different traits are considered. The genetic correlations between the two sites along with estimates of heritabilities can be used to solve the problem. High genetic correlation indicates that the two environments represent very nearly the same characters and the same set of genes is operative in both environments.

Thus selection can be done in either of these environments. If we suppose X as yield in high environment and Y in low environment, then the improvement of Y is estimated as a correlated response (CR) and the expected rate of improvement is:

$$CR_y = ih_x h_y r_\theta \sigma_{Py}$$

where i = intensity of selection, h_x and h_y are the square roots of heritabilities of X and Y measurements, σ_{Py} is the phenotypic standard deviation of Y.

Thus if we have estimates of genetic correlations and heritability in two environments we can predict the performance in an environment different from the one in which selection was carried out. In order to compare the improvement from indirect selection vis-a-vis from direct selection of Y (the performance in the environment for which improvement is desired) we may compute:.

$$\frac{CRy \quad \text{Response from indirect selection}}{Ry \quad \text{Response from direct selection}}$$

$$= \quad r_\theta \frac{i_x h_x}{i_y h_y}$$

This will show whether we gain from direct or indirect selection. If r_θ is high, it will make little difference in which environment selection is carried out. But if r is low, it will be better to do selection in the environment in which the material is to grow.

Correlations and heritability estimates for selection of environments

Johnson and Frey (1967) pointed out that heritability estimates would indicate the most effective environment for selection. A high heritability in the test environment would maximise genotypic differentiation based on genetic variation. Vela-Cardenas and Frey (1972) both heritability and genetic advance estimates have been used by others as criteria for choosing environments.

Allan et al. (1978) found that the proper measure of test environment value is r JH where r is the correlation between the values of genotype in the jth environment and the overall mean of all environments. Estimates of JH for low, intermediate and high-yielding environments did not differ greatly in five crop species i.e. barley, wheat, oats, soybean and flax. The indicated advantages of high-yielding environments over intermediate environments to be 4 and 7% respectively, for wheat and soybean, but in the case of barley, oats and flax, there were no indications that high-yielding environments were superior. They suggested that it is the estimate of r which will determine the superiority of environments as superior testing sites for that class of environments.

Concurrence of regression lines and choice of environments

Significant correlation between mean performance and regression coefficients has often been observed in plant breeding data indicating that the regression slopes of different genotypes pass through a common point (Eagles et al. 1977). Differences between mean performance of genotypes disappear at that point. It is possible to partition heterogeneity among regressions sum of squares into 1 d.f. for concurrence of lines. Chahal and Virk (1984) and Virk et al. (1984) found that concurrence lay outside the range of testing environments. Apparantly the chosen environments were effective in genotypic differentiation.

The occurrence of concurrence implies that the Y_{ij} values can be regressed with a similar success on genotype or environmental values (Wright 1971). When a model with regression of Y_{ij} values on genotypic effects is important then selection for general adaptation will be an efficient strategy. When a model of regression on environmental means is important (and regression is concurrent), then the best selector environment can be chosen on the basis of the mean performance i.e. the environments may be advantageously grouped simply according to their mean values and the production of specific varieties for good, average and poor environments may be more efficient.

Pollmer et al. (1980) estimated screening ability and differentiation ability of environments. The differentiation ability of environments is based on the regression coefficients of Y_{ij} values on to genotype means where high coefficient indicates high differentiation ability. The screening ability of jth environment $(Z_j) = r^2_j h^2$ where r_j is the correlation between genotypic performance in the jth environment and over all environments, and the h_2 is the heritability estimate of mean values in the jth environment. A high Z_j values indicates better screening ability of the environment.

Multivariate analysis

Multivariate analysis has been used for classification of environments. Two multivariate techniques, cluster analysis and pattern analysis (Williams and Gillard 1971) are used.

Abou-El-Fittouh et al.(1969) used pattern analysis (cluster analysis) of environments to identify subsets within which g x e interaction was reduced in cotton. Byth et al. (1976) used this analysis for classification of environments as well as genotypes. Shorter et al. (1976) used pattern analysis to characterise the contribution of individual environments. They formed hierachical fusion groups of environments for their classification into different groups. Contribution of environments to ordination represents a principal coordinate analysis (Gower 1966). The contribution of an environment to any principal axis is reflected in the relationship between the performances of the tested lines in that environment and their coordinates on the principal axis in question.

Zoning and varietal testing under all India coordinated crop improvement projects (AICCIPs)

India is a vast country with diverse environmental conditions. There is a wide range in rainfall, temperature, soil type and biotic and abiotic stresses experienced at different places. Both cropping patterns and practices of cultivation differ widely. The hilly regions have extremely cold conditions which vary considerably between the lower ranges, valley areas and higher hills. Thus genotypes developed in one region may not show the same performance in all other areas.

Zoning

The AICCIPs on different crops are concerned with cultivar improvement for the entire country. Keeping in view the diversity of climatic and edaphic factors, the country has been divided into different zones for different crops (Table 1). Zoning varies with the crop and is based on the geographical features of the country. Depending upon the areas of cultivation of a crop, the zoning is crop specific.

Table 1. A summary of zones currently prevalent in different All India Coordinated Crop Improvement Projects

Wheat	:	Northern Hills Zone; North Western Plains Zone; North Eastern Plains Zone; Central Zone; Penninsular Zone; and Southern Hills Zone
Rice	:	Zone I (North Western Plains and Southern States); Zone II (North Eastern States); and Zone III (North Hilly areas).
Cotton	:	Northern Zone; Central Zone; and Southern Zone
Maize	:	Zone I (Himalayan areas including North Eastern Hill region) Zone II (North West Plains Zone); Zone III (North East Plains Zone); Zone IV (Penninsular areas); and Zone V (Central India)
Pearl Millet	:	Zone A (areas with less than 400 mm rainfall); and Zone B (areas with more than 400 mm rainfall)
Sugarcane	:	North Western Zone; North Central Zone; North Eastern Zone; and Penninsular Zone
Oilseeds	:	Rapeseed and mustard: 6 zones
Sesame	:	4 zones
Linseed and Sunflower	:	3 zones
Groundnut	:	1 zone e.g. for sunflower : Northern Zone; Central Zone; Southern Zone.
Pulses	:	North Hills Zone; North West Plains Zone; North East Plains Zone; Central Zone; and Southern Zone
Forages	:	Hill Zone; North East Zone; North West Zone; Central Zone; and Southern Zone

Varietal evaluation

The constitution of varietal trials and their conduct varies from crop to crop. In crop like wheat the entries in Initial Varietal Trials (IVT) are contributed by different breeding centres on quota basis after having evaluated in Initial Rust Screening Nurseries across the country irrespective of zones. The IET and advanced Varietal trials (AVT) are conducted zone wise. The number of locations varies from 10-12 for IET and 20-25 for AVT. A variety has to be tested for three years prior to its identification. In these trials there is no system to test a variety across zones. However, National Yield Observation Nurseries have been introduced to fill up this gap. In cotton, the varieties are tested in trials allocated species wise in particular zones. In the intra-*hirsutum* hybrids trials conducted under irrigated conditions the entries from central and south zones are also tested in north zone. Likewise in *hirsutum* x *barbadense* hybrid trials, entries are contributed by different centres in the country for testing in north Indian conditions. In maize, zonal trials are conducted but they are as good as state trials since two locations data are required for inclusion of entries in the IET. However, zonal performance is considered to promote the entries in coordinated trials and for release. Although zones are demarcated, the testing for release has not necessarily been done at zonal basis. Three series of trials marked A,B,C, depending upon the maturity groups are conducted. In pearl millet and forages, all entries are tested throughout the country but the data are

presented zonewise and for the entire country. In sugarcane, the trials are conducted according to zones. For contributing varieties for IET one year plant crop data is required and there is no restriction for the number of entires. In oilseeds, the number of zones varies for different crops. The same set of varieties is tested in different zones. In pulses, the testing is done zone wise. Entries in IET are, however, tested across zones in the first year and the top entries are promoted on the basis of zone means.

The foregoing system of zoning and varietal testing has yielded good results. However, there is a scope for improvement on scientific basis.

At present, zoning for different crops is entirely based on geographical boundaries. The areas covered under each zone are too vast and have a further scope for division into subzones. For instance evan a small state like Punjab with 1.5% area of India (29.33' to 32.31' N latitude and 73.55'E to 76.55'E longitude) is divided into six zones: Sub-mountain undulating region, Undulating plain region, Central plain region, Western Plain region, Western region, and flood plain region. The cropping patterns in all these zones are different because of differences in rainfall, underground water, soil type and climate.

When subzoning within a zone is made it is essential to ensure an optimum range of locations within the subzone. The selection of locations should be made on scientific basis so that maximum differentiation among varieties is achieved with minimum cost. The minimum number of test sites needs to be worked out in this respect.

Reporting of data of trials under coordinated projects is often not perfect. Some centres do not opt for conduct of certain trials while at some others the trials are poorly conducted which have very low yield levels or exceptionally high CV. The major constraint is generally the shortage of funds. It, therefore, needs no emphasis that availability of liberal grants is the pivot of quality research and needs to be ensured for all centres in various projects. Further, liberal grants for the establishment of location specific regional stations or strengthening of already existing centres are required so as to make location specific research to be more meaningful.

In the testing of varieties, it is essential to infuse a team spirit among scientists of various disciplines. Coordination among scientists within a project is very essential but it should also be extended across projects so that there is a free and frank interaction among personnels of different projects.

The development and identification of varieties for wider cultivation or specific adaptation depends upon the response of varieties to a range of environmetal spectrum. It is the variety which will determine its areas of cultivation. Therefore, it becomes imperative to use varietal data for grouping of environments into zones rather that just basing the zoning on geographical demarcations. A number of methods based on (i) the technique of analysis of variance for grouping of environments with non-significant g x e, (ii) contribution of environments to genotype x location (g x l), (iii) correlation matrices, (iv) genetic parameters like heritability and genetic correlations, (v) differentiation ability and screening ability of environments, and (vi) multivariate analysis are available. None of these scientific techniques has been employed for classification of environments into zones in the AICCIPs. The geographical zoning

may become arbitrary in light of responses of genotypes which need to be considered. This may be achieved in each crop by examining the date of varietal trials over many years across locations. The grouping of locations in this way may perhaps run counter to the geographic zones in certain cases. The same techniques can be applied for subzoning with specific locational properties. The geographic zoning is better than no zoning and was a beginning.

Zoning vis-a-vis testing of varieties

The next question relates to the testing and release of varieties. At present there is no uniform pattern of varietal testing in different crops. While in some crops testing is only on zonal basis, in other crops the evaluation is made across zones and the data are only summarized on zone basis. The first system is advantageous in respect of conduct of trials as there will be fewer entries. This means that the conduct of trials is more precise. Also the number of locations being a few the reporting of data is almost ensured. Since the varieties are to be released for specific locations the extra expenditure involved on the testing of unadapted varieties from other zones is saved. The second system has the advantage of uniform trials being conducted at all locations and helps in determining which varieties have adaptation to specific zones and which have a wider adaptation. Furthermore, it will not be possible to detect a near ideal genotype from plant breeder's and farmer's point of view unless it is tested over all possible environments even if it is present in the sample. Near ideal genotype is the one that performs reasonably even in the low yielding environments but combines the capacity to favourably respond to high yielding environments leading to higher yield performance (Verma et al. 1978). If only zonal testing is done there is a likelihood that some superior variety with specific adaptation to a particular area might not be tested in the locations of its adaptation. This will lead to national loss in terms of release of a good variety. It is therefore essential to ensure testing of all entries throughout at initial stage of testing.

Apparently, this system of testing all entries across all locations at the initial evaluation level is being followed in some crops. This practice may be extended to other projects where possible. Alternatively, national nurseries existing in some crops may be used for this purpose. The entries for zonal testing then can be selected and entered into varietal trials. In self pollinated crops, the seeds of locationally adapted entries can be multiplied and even saved from evaluation trials but it is not so in case of cross pollinated crops where the balance seed has to be used.

Promotion of entries

The selection of a variety, when g x e interactions are present, would depend upon the choice of sites and years. A narrow range of high yielding trials would tell a very different story from a similar range of low yielding environments. Indeed if the ranges are very narrow, no regression might be apparant at all and the decisions could be very inappropriate. Thus it is not only necessary to ensure inclusion of appropriate locations in variety evaluation trials but also to compute appropriate analysis of variance and analysis of stability so as to assess the relative responses of varieties in varietal promotion. In general, the varieties are promoted by comparing the mean values with the check varieties only. No sophisticated analysis is performed in most

of the projects. Only in two cases it is proper to compare varieties by a single parameter when $\hat{b} = 1$, $\hat{a} \pm 1$ and $\hat{b} \pm 1$, $a = 0$. In the first case the varieties differ by a constant amount of yield and in the second by a percentage of yield. More generally, therefore the two parameters a, and b are required to compare varieties. The comparison on the basis of mean values assumes absence of interactions and is only valid if intercept $a = 0$. This can also be valid in a trivial case of a range so narrow that there is no regression. The empirical observation from regression analysis leads to the economy in trials by concentrating fewer trials into high and low-yielding environments. Alternatively, it might be feasible to create contrasting environments by varying treatments as in agronomic trials of irrigation or stress vs. non-stress etc. For varietal promotion, the regression analysis of stability should therefore be performed and the parameters of stability worked out. Also the analysis be used for the choice of environments.

In most of the varietal trials the error variances are heterogeneous which may invalidate the analysis of variance and the regression analysis of stability. In these situations a weighted regression analysis technique of detection of cross over interaction may be employed (Virk et al.1991, Virk and Mangat 1991). These techniques are also useful in clustering of variations in CV from environment to environment (Virk et al. 1984) and environments that show noncross over interactions across genotypes as well as selection of varieties for specific or general adaptation.

Conclusion

The present system of zoning in the All India Coordinated Trials has served a useful purpose in identification of varieties of different crops suitable for different agroclimatic zones, essentially based on geographical areas. These need to be reviewed in light of numerous biometrical developments in the area of genotype x environment interactions. Repatterning of zones on the basis of these techniques using the vast data on trials collected over years and locations is thus recommended. This exercise should be taken up in each project.

Subzones within large zones may also be demarcated for evaluating the materials for breeding specifically adapted varieties. Still variations in crop yields exist within zones which can be minimized if locations specific research is undertaken. This strategy offers a great scope in boosting productivity levels.

Varietal testing must involve some sort of testing across zones as well as for the individual zones. The promotion and identification of varieties should not only be made on the basis of mean performance but also should take into consideration other parameters that define the behaviour of varieties across environments. It may be more appropriate to breed varieties with specific adaptation rather than breeding for wider adaptation.

REFERENCES

Abou-El-Fittouh HA, Rawlings JD, Miller PA (1969) Classification of environments to control genotype by environment interactions with an application to cotton. Crop Sci 9 : 135-140

Allan FL, Comstock RE Rasmusson DL (1978) Optimal environments for yield testing. Crop Sci 18 : 747-751

Allard RW, Bradshaw AD (1964) Implications of genotype environmental interactions in applied plant breeding. Crop Sci 4 : 503-508

Borlaug NE (1965) Wheat, rust and people. Phytopathology 55 : 1088-1098

Boyd WJR, Goodchild NA, Edwards CS (1977) Unpredictable environmental variation and plant breeding strategies. Proc 3rd Int Cong SABRAO. Canberra Feb.1977 Sent3(d) pp 46-50

Brennan PS, Byth DE (1979) Genotype x environmental interactions for wheat yields and selections for widely adapted wheat genotypes. Aust J Agric Res 30 : 221-232

Byth DE, Eisemann RL, De Lacy IH (1976) Two-way pattern analysis of a large data set to evaluate genotypic adaptation. Heredity 37 : 215-230

Chahal SS, Virk DS (1984) Multilocation evaluation and selection of stable genotypes for reaction to downy mildew in pearl millet. Crop Prot 3 : 95-102

Comstock RE, Moll RH (1963) Genotype-environment interactions. In : W.D. Hanson and H.F.Robinson (ed.) Statistical genetics and plant breeding. NAS, NRC Pub 982. pp 164-196

Eagles HA, Hinz PN, Frey KJ (1977) Selection of superior cultivars of oats by using regression coefficients. Crop Sci 17 : 101-105

Falconer DS (1960) Introduction to quantitative genetics. Longman London

Frey KJ (1964) Adaptation reaction of oat strains selected under stress and non-stress environmental conditions. Crop Sci 4 : 55-56

Gower JL (1966) Some distance properties of latent root and vector methods used in multivariate analysis. Biometrik 53 : 325-338

Horner TW, Frey KJ (1957) Methods for determining natural areas of oat varietal recommendations. Agron J 49 : 313-315

Jinks JL, Connolly V (1975) Determination of environmental sensitivity of selection lines by selection environment. Heredity 34 : 401-406

Johnson GR, Frey KJ (1967) Heritability of quantitative attributes of oats (*Avena* sp.) at varying levels of environmental stress. Crop Sci 7 : 43-46

Perkins JM, Jinks JL (1971) Specificity of the interaction of genotypes with contrasting environments. Heredity 26 : 463-474

Plaisted RL, Peterson LC (1959) A technique for evaluating the ability of selections to yield consistently in different locations or seasons. Am Potato J 36 : 381-385

Pollmer WG, Eberhard D, Klain O, Dhillon BS (1980) Stability of performance of high protein maize. In: W.G. Pollmer and R.H.Phipps (ed.), Improvement of quality traits of maize for grain and silage use. Martinus Nijhoff Publishers b.v. London, pp 257-272

Roy NM, Murty BR (1970) A selection procedure in wheat for stress environments. Euphytica 19 : 509-521

Shorter R, Byth DE, Munigomery VE (1977) Genotype x environment interactions and environmental adaptation.II. Assessment of environmental contributions. Aust J Agric Res 28 : 233-235

Tsai KH, Lu YL, Oka HI (1970) Studies on soybean breeding in Taiwan. 4. Adaptability to fall cropping explored by disruptive seasonal selection of hybrid populations. SABRAO Newsl 2 : 91-102

Vela-Cardenas M, Frrey KJ (1972) Optimum environment for maximising heritability and genetic gain from selection. Iowa State J Sci 46 : 381-394

Verma MM, Chahal GS, Murty BR (1978) Limitations of conventional regression of analysis - a proposed modification Theor Appl Genet 53 : 89-91

Verma MM , Gill KS, Virk DS (1987) Genotype - environment interaction - its measurement and significance in plant breeding. Communication Centre, Punjab Agricultural University, Ludhiana. pp 1-101

Verma MM, Kumar J (1974) Breeding for yield in self pollinators - an introspection and reorientation. Crop Improv 1 : 15-31

Virk DS, Mangat BK (1991) Selection of cross over genotype x environment interactions in pearl millet. Euphytica 52 : 193-199

Virk DS, Singh NB, Srivastava M, Harinarayana G (1984) Regression analysis for general adaptation in pearl millet using different environmental indices. Theor App Genet 68 : 509-513

Williams WT, Gillard P (1971) Pattern analysis of a grazing experiment. Aust J Agric Res 22 : 243-260

Virk DS, Virk PS, Mangat BK, Harinarayana G (1991) Weighted regression analysis for comparing varietal adaptation. Theor Appl Genet 81 : 559-561

Wright AJ (1971) The analysis and prediction of some two factor interaction in grass breeding. J Agric Sci Camb 76 : 301-306

Role of All India Coordinated Crop Improvement Projects and their Linkages

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For implementing the research policies and programmes, the Indian Council of Agricultural Research (ICAR) as a national coordinating agency in the field of agricultural research, developed national grid comprising of Central Research Institutes, National Research Centres, All India Coordinated Crop Improvement Projects (AICCIPs), State Agricultural Universities (SAU) and voluntary organisations. ICAR also established linkages with several national and international organisations. Linkages among the AICCIPs on one hand and between the projects and relevant institutions on the other have not been well established to develop location specific component and systems technology for the resource poor small and marginal farmers belonging to 95 million farm families.

Historical background

The AICCIPs is a unique mechanism in building a nation wide cooperative interdisciplinary research net work linking ICAR Institutes with the SAU to focus attention on commodities of national importance. There are 85 such projects today and most of them have been operating continuously for over a decade and some even for three decades such as Maize and Agronomy (now called Cropping System Research Directorate) projects.

The All India Coordinated Agronomic Research Project (AICARP) is the oldest project, operating form 1953, almost four decades old. Others started operating during subsequent Plan periods. The AICCIP concept was to pool together the national resources, technical and material, for effecting a break through in production by generating improved technology through interdisciplinary research and, evaluating the suitability, adaptability and transferability of technology to different ecological regions. They have proved to be the most effective instruments for the development and transfer of improved technology and for creating cooperative research net work in the country. The important role these projects have played in increasing agricultural production is well known. The scientific break through which heralded the era of the "Green Revolution" has yielded spectacular results. Foodgrain production has increased from 50.8 mt in 1950-51 to 178 mt in 1990-91. The new technologies that have been developed during this period have enabled many small farmers to cross the threshold of non-viability. The rise in employment opportunities on on-farm and ancillary enterprises have contributed to increases in real wages.

However, there is no quantum jump in agricultural production and productivity during the past two decades in spite of both national and international efforts. There is thus a need to accelerate the rate of growth of production to meet the challenges of the future. Any complacency in this regard

could be a great danger. To achieve this goal, the planning should be at the microlevel involving each agro-ecological region, and for this purpose research results should get closer to land. The whole approach of the agricultural planning should be decentralised and location specific. AICCIPs contribution to this development process will be important in addition to providing a major leadership in stimulating research, promoting ideas and ensuring research support.

Accomplishments

As a result of concerted efforts, performance in crop science has been quite impressive. A number of high yielding varieties/hybrids possessing inbuilt resistance/tolerance to various biotic and abiotic constraints were identified and released: cereals-120, oilseeds-65, pulses-48 and commercial crops 28. Similarly a number of crop combinations and highly rewarding cropping systems in different regions and agroclimatic conditions using newly evolved varieties and hybrids have been worked out. Easily adaptable and economically viable integrated pest management strategies have been developed for the control of major pests. These and the development of matching technologies with emphasis on low cost inputs have opened a whole range of new avenues for stepping up area, production and productivity of crops in dry lands. Contingency crop planning under rainfed condition with the progress of the season, and emphasis on fodder based cropping systems have been evolved. The technologies for reclaiming alkali soils were further refined and widely adopted. An integrated management of weeds with tillage implements and herbicides has been worked out.

Gaps and deficiencies

In the last 25 years, there has been much expansion and multiplicity of the AICCIPs and in many technical, operational or administrative problems have cropped up. The research capabilities of the States have considerably improved with the establishment of SAU and the availability of a large number of qualified and competent scientists has increased. A chain of regional research stations under the National Agricultural Research Project (NARP) all over the country have been created, directly controlled by SAUs. It is, therefore, necessary to consider whether AICCIP really conforms to the philosophy of interdisciplinary research targets to a product, how long should a project run to achieve its objective, the mechanism of the functioning, and the pattern of funding. The silver lining in the concept and operation of the AICCIPs is that the Project Headquarters and the centres are located within SAUs.

Over the years the drawbacks mentioned above have threatened the very concept of evolving improved technologies through cooperative efforts. The noticeable few are inadequate focus on local problems in research programmes, excessive emphasis on uniformity of the experiments, straight jacket approach in research, lack of effective monitoring and weak link with extension and inadequate financial resources.

There are large number of AICCIPs with multidisciplinary approach while there are comparable number of discipline oriented projects with multicrop (cropping systems) approach. For example while in rice, wheat, maize, sorghum, millet, pulses, oilseeds projects there are breeders, agronomists, pathologists and entomologists working on a given crop, there are professionals in

Agronomy (Cropping system), Dry Land, Long term Fertilizer, Water Management, Micro-nutient, Organic matter, Agricultural Physics Projects etc., working on the very same crops possibly at the same centre/ State/agroclimatic zones. Most often the linkages among various projects located at the same centre and other centres within the region/state and at the project levels are seriously lacking. Some of them are listed as below.

- While the prerelease varieties are being developed in the AICCIPs, the subject/discipline oriented projects are engaged in testing the out dated and old released varieties in their experiments.

- Similarly while the subject/ discipline oriented projects are adopting more scientific and modern production technology, the AICCIPs are following the traditional cultural practices.

For example there is a switch from upland crop (maize, sorghum millet)-wheat cropping system to lowland rice-wheat system in Punjab, Haryana, Uttar Pradesh and in other states. With the change in texture of the soil (from light to loam or heavy soil) where rice-wheat system is being practiced now, the time and frequency of irrigation are bound to change for both crops and more particularly for wheat crop. Last irrigation to rice is cut off about 15 days before harvest. Wheat now requires 2-3 post sowing irrigations with first irrigation 4-5 weeks after wheat sowing. Rice planting is advanced to May / June and harvesting is completed by first week of October, with the result that 15-20 days time are available between harvest of rice and sowing of wheat for land preparation. The questions that arise are:

- Whether the breeders, agro-nomists, pathologists and entomologists in the crop Projects are taking conginzance of such changes in the cropping system, water, fertilizer and weed management and designing their research trials accordingly.

- Whether the prerelease disease and pest resistant varieties are being adequately multiplied and supplied to subject/discipline oriented projects for their evaluation.

- Whether the subject/discipline oriented projects are coommunicating their modern production technology to AICCIPs for adoption in experiments where the breeders, pathologists and entomologists are engaged in developing new varieties.

- Whether the prerelease varieties, crop production and crop protection technologies supposed to come to advanced stage are being tested on representative farmers' fields with their full participation in testing, evaluation and analysing the results.

- Whether independent agencies are being employed for such on-farm testing (other than those are involved in actual development of varieties and technologies).

- Whether the results of relevant crop and discipline oriented projects are being presented at the same platform in annual/half yearly workshops of the relevant crops. Whether the social scientists have been deeply involved in examining the results for productivity, profitability, quality, acceptability and sustainability?

Whether the final recommendations take into consideration the results of on-farm trials under AICARP (now CSRP) and minikit trials. Whether such recommendations from various projects are screened, compiled, published and circulated to the concerned Departments at the centre and state levels.

- Whether there are meetings of Deputy Director Generals of various divisions in ICAR to evaluate the performance of their recommendations at the field level? Do they analyse the causes of failure if any? Do they get feed back from the field for redesigning their strategy? Do they ensure linkages with the Development projects in the line (User) departments at Centre and state levels. Have they designed and mounted any diagnostic survey to identify the production constraints and prioritize them? The constraints may not necessarily be of technological nature. These may be classified into socio-economic, bio-physical, institutional, administrative and procedural. Can the council not coordinate with the appropriate agencies to remedy these situations?
- What has been the rate of adoption of a given technology or variety at the field level particularly by the small and marginal farmers?
- Whether adequate research-extension linkages have been ensured

Strategy and approach in the VIII Plan

The present practice of developing a common programme for all the centres at the national workshop meeting would have to be reconsidered. The research programme from now on should be developed by the researchers mainly to meet the needs of the States and its farmers in different agroclimatic zones and farming situations..

- Production technologies are essentially site specific. Promoting research in this area will require identification of specific problems and time bound programme to find viable solutions.
- Regional problems in the coming years will become increasingly complex. Finding solutions to these will require an increasing understanding of the basic resources, abilities to quantify these and various interactions.
- Solution to increasingly complex problems will require organisation of multidisciplinary teams.
- Increased emphasis on the socio-economic aspects in relation to the farming systems research keeping in view the existing and emerging needs.
- On-farm research and farming system research will need to be integral parts of each of the major programmes.

Priority and thrust areas for research at the national level

The recommendations by the Working Group on Agricultural Research and Education at Planning Commission under the Chairmanship of Dr.M.S. Swaminathan are given below.

- Increasing productivity and efficiency of irrigated farming

through greater emphasis on research on soil and water management.

- Rainfed farming and dry land technology.
- Improving efficiency of inputs in agriculture.
- Breaking yield barriers of wheat and rice and increasing productivity and stability of yield of pulses, oilseeds and rabi sorghum.
- Concern for fuel and fodder.
- Fighting drought and nutritional stress.
- Management of biotic stresses.
- Processing and marketing.
- Recognizing the importance of genetic resources.
- Strengthening research in less developed areas.
- Energy management.
- Farm machinery and management.
- Research in Home Science.

The nineties will be a critical decade in our agricultural history. Large increases are needed in production of rice, wheat, pulses, oilseeds, fodder, food grains, fuel, fruits, vegetables, milk, meat and egg and in a wide range of other crops. Such increases will have to come not only from our diminishing land resources but under expanding biotic and abiotic stresses. The economic viability and ecological sustainability of advances in terrestrial and aquatic productivity will have to be insured on a concentrated farming system research so that productivity per unit time and space increases to meet the demand of rapidly growing population in the country.

Strengthening linkages

In the field of agriculture, integration of research, education and extension has been promoted in the SAUs and the ICAR Institutes. In some cases the integration/collaboration with various Institutes/Projects are formal while in others the mechanism for linkage is weak or non-existant. Some of the desirable linkages at the scientific, technical and organisational levels with the AICCIPs' are listed below:

- International cooperation within SAARC region. Bilateral cooperation with individual countries and multilateral cooperation with organisations such as UNDP, FAO, CGIAR Institutes, Common Wealth Institute of Biological Control etc.
- National linkage with ICAR Institutes, SAUs, CSIR, BARC, line departments of the State Govts.
- Most important of all the linkages is the linkage among AICCIPs and those under the Divisions of soils, Agronomy and Agroforestry and Transfer of Technology in the matter of selection of right varieties and production technology.

- The results of research of Technology Transfer Projects/On-farm trials under AICARP, and minikits should be discussed in the relevant workshops. Before recommendations are finalised, the social scientists (Economists, Sociologists and Statisticians) should examine the results critically for their productivity, profitability, acceptability, stability and sustainability. Actual recommendations for package of practices should be made after the results of multilocation on-farm trials (carefully conducted on

objectively selected farmers' field through standard sampling design) are statistically analysed for individual agroecological regions. There are large number of centrally sponsored schemes run by the State Departments of Agriculture on rice, wheat, maize, millets, oilseeds, pulses, fertilizers, implements, micronutrients etc. Substantial operational funds are available in these projects for on-farm trials. A complete linkage should be established between these schemes and AICCIPs which are mutually beneficial.

- The linkage can only succeed if individual centres of AICCIPs are allowed to take creative research, technology refinement research and uniform all India experiments at 25:25:50% of time and resources.
- The linkage can be continuously updated through annual meetings of the Coordinators/Principal Investigators of various projects and repeated training/orientation programme specially designed for the purpose.
- Similar exercise should be undertaken at the State level with SAU and line departments of State/Central Governments. The SAU should in turn develop linkages with rural Universities and women Universities.
- At least 50% of the research work of any AICCIP should be on the farmer's fields in the form of on-farm adaptive research with full participation of the farmers.
- Linkage requires not only technical/scientific input but also socio-psychological input. Accountability for proper linkages has to be fixed on Project Coordinators/Project Directors and for non-performance, necessary follow up action specially by the concerned DDGs. For successful performance of such collaboration, the individuals concerned should get appreciation and encouragement through reward. There is tremendous scope of reducing the number of field experiments, by replacement of old varieties/outdated technologies if linkages are established as mentioned above.
- Interdisciplinary team work among allied scientists including social scientists must be emphasized in the interest of quality research work and generating location specific technologies. The extension staff of the line departments of the State Government, clientele group comprising farmers, farm women and representives of industrial sector must be involved in planning, implementation, review, recommendation and follow up of any AICCIP.
- In both cropping and farming systems research there is need for developing appropriate methodologies and training and orientation to the Scientists. Farming systems research would mean a lot more interaction and linkages with allied disciplines including even the nonagricultural sectors.
- Funding for the AICCIPs should be adequately taken care of by Government at both centre and at states.

Farming system research

The limitation of the conventional model of agricultural research and extension in

dealing with the interactive matrix are well recognised. Presently AICCIPs focus their attention with emphasis on component research and not much is done to develop system based programme. The response of a crop to component technology in isolation is different than that in systems perspective, which considers both positive interactions and competitions among components. The individual programme ignores the socio-economic and biophysical aspects of the farming community. Farming System Research (FSR), if made a part AICCIPs, will enable the Projects to identify the farm constraints and provide researchable issues to component technology priorities, strategies and resource allocation decisions and through it to identify and adopt technologies useful to location specific group of farmers.

The main aim of FSR is to develop sustainable land use systems which will promote the farm resource use, increase income and employment for farm families and provide quality life and environment. The FSR will enable us to identify the constraints in increasing sustainable farm productivity, will provide technological intervention options for improving farming systems with a given resource base, will help in refinement and development of appropriate farm technology and will provide feedback to on-station researchers and to develop methods for measurement of sustainability of productive systems.

The scope of FSR includes various farming enterprises such as crop, livestock, poultry, fish, tree crops, plantation crops, sericulture, etc. A combination of one or more enterprises with cropping, when carefully chosen, planned and executed, gives greater dividends than single enterprise specially to small and marginal farmers.

The methodology of FSR consists of five stage: Descriptive and diagnostic, Design, Testing, Evaluation and Extension. At each stage, multidisciplinary efforts by a team comprising of crop scientists, social scientists, and specialists in livestock, fishery, forestry, tree and plantation crops and farm management are essential to carry out the FSR programme.

In view of serious limitation on horizontal expansion of land for agriculture, the only alternative left is for a vertical expansion through various enterprises requiring less space and time but giving high productivity and ensuring periodic income specially for the small and marginal farmers belonging to handicapped zones (rainfed areas, dry lands, arid zone, hilly areas, tribal belts and problem soil areas). For this, several farm enterprises could be combined as follows: Crop + livestock; Crop + livestock + poultry; Crop + horticulture, Crop + horticulture + sericulture; Rice + fish; and Rice + fish + mushroom.

For meaningful execution of integrated farm enterprises, the activities need to be undertaken by a multidisciplinary team of scientists with farmers' participation and involvement at all stages would be through understanding of existing farming systems and their components, assessment of resource availability in the farm environment and identification of biophysical, socio-economic, institutional, administrative and technological constraints, development of economically viable and efficient integrated farming system suitable for various domains, diffusion of improved technologies and receiving feedback for their improvement of the system as a whole, continuous improvement in component technology to fit into a given farming system, improvement in quality of farming system

research, research-extension linkage through on-farm adaptive research and National and International linkages.

The FSR programme should facilitate the evaluation of the respective technologies on farms in identified priority regions, the essential linkages among research, extension, infrastructural research systems and development agencies, to assess the consequences of new technology and to derive implications for future research priorities and strategies.

The national scientists must, therefore, be suitably trained and their knowledge should be continuously updated and sharpened in the practices, principles and methodology of FSR and research extension linkage.

The ICAR, as the apex body, should have a separate Deputy Director General exclusively handling FSR programme. DDG (FSR) should be able to coordinate with other DDGs at the head quarters and among ICAR research institutes, SAUs and relevant coordinated projects, compile and synthesise the available farming system technologies, and give direction for further research.

The DDG (FSR) shall chair a steering committee consisting of DDG (SAF), DDG (AE), DDG (CS), DDG (AS), DDG (Hort), DDG (Fishery), ADG (Agroforestry), ADG (Agronomy), ADG (Soils), ADG (Eco), Government of India Commissioners in Animal Husbandry and Fisheries, Directors of IARI, IVRI, IASRI and PD, CSR, the ADG (FSR) should be the conveners. The DDG (FSR) should provide effective linkage between research and development departments at centre and states and at SAUs.

Recommendations

Scientific/Technical

There should be complete understanding among the projects about the agroclimatlogical requirements of individual crops and cropping/farming systems.

Each project should delineate the areas on the basis of predominant cropping/farming systems and the research be widely conducted for drawing valid conclusions for each domain.

Projects must look at the districts with high spread of a given crop or a cropping system but giving chronically low yields, analyse the causes and develop research strategy in those areas. This aspect has been thoroughly neglected in the past.

Prerelease varieties, crop production and crop protection technologies having come to advanced stage must be tested through on-farm trials with farmers' participation and should not be released before evaluation and analysis of the results of such trials.

The results of relevant crop and discipline oriented projects should be presented at the same platform in annual/half yearly workshops.

The final recommendations emerging from various projects should be screened, compiled, published and circulated to the line Departments at the Centre and States.

Social scientists should be involved in each project so that the results could be examined for productivity, profitability, quality, acceptability and sustainability.

Studies should be initiated by each project to measure the rate of adoption of a

given technology or variety at the field level.

Before deciding any research strategy each project should undertake a diagnostic survey to identify the production constraints and prioritize them.

Actual recommendations should be made after the results of multilocation on-farm trials are analysed for individual agroclimatological regions.

Organisational

The DDGs of various Divisions in ICAR should sit together to evaluate the performance of their recommendations at the field level and get the feedback periodically to formulate new research programmes/strategies.

The linkages among the projects should be continuously updated through annual meetings of Coordinators of various projects. Similar exercise should be undertaken at state level with SAU and line departments.

The FSR/on-farm adaptive research should be part of each coordinated Projects.

The final testing of varieties and production technology should be in the farmers' fields under an independent agency not connected with development of varieties/technology. For example new variety must be tested in the on-farm trial component of the Directorate of Cropping System Research and production technology developed by the agronomists, soil scientists and others should be tested in National Demonstrations, Lab to land and Operational Research Projects.

The ICAR as the apex body should have separate DDG exclusively handling FSR Programme. DDG (FSR) should coordinate with other DDGs at the head quarters and ICAR research Institutes, SAUs and relevant coordinated projects and compile and systhesise the available farming system technologies and give direction for further research through a steering committee.

Linkage

AICCIP's should establish close linkages with International and National Organisations.

Close linkages should be established among researchers in different projects and the results of research should be discussed in the relevant workshop jointly.

Large number of centrally sponsored schemes are presently run by State Departments of Agriculture. A complete linkage should be established between these schemes and AICCIP's for mutual funding and benefit.

The linkages require not only scientific/technical input but socio-psychological input.

Accountability for purpose of linkage should be fixed with the Project Coordinators/Directors.

Infrastructure and funding

There should be single window delivery system of all the available technologies in the country to avoid duplication and confusion and thereby ensure faster adoption of the technology by the farmers with the help of concerned extension agency.

Prerelease varieties resistant to diseases and pests should be adequately multiplied

and supplied to subject/discipline oriented projects for evaluation, specially on farmers fields.

Facilities for Extension Education Programmes of SAUs, Transfer of Technology Projects and on-farm trials should be so dispersed that every low yielding districts, (drylands, hilly areas, tribal areas, problem soils) are adequately covered.

More attention has to be paid to the States/SAUs where per hectare yields of crops are low but potentialities are high. In this connection the eastern states (eastern Uttar Pradesh, Bihar, West Bengal, Assam, north-eastern States, Orissa and eastern Madhya Pradesh) need special attention by way of infrastructure development for research and research-extension linkage.

Percapita investment on research and education should be carefully studied in relation to each of the states/coordinated projects and their relevance. Adequate funding for development of location specific technology and its transfer to target group is of paramount importance.

REFERENCES

ICAR (1988) Report of the ICAR Review Committee. Krishi Bhavan, New Delhi

ICAR (1990) Strategy and approach to VIII Plan. Krishi Bhavan, New Delhi

Mahapatra IC (1984) Priorities and strategies of cropping systems and farming system research in India In: 15th Annu.Workshop, All India Coordinated Agron Res Proj, Jaipur, (1984). August 27-29, 1989

Mahapatra IC (1991) Rice farming systems research development concept and policy direction. In: Workshop on Policy Issues for Increasing Rice Production, Directorate of Rice Research, Hyderabad, September 3-6, 1991

Mahapatra IC, Bapat SR (1991) Integrated approach for research-extension linkage in increasing agricultural production. In: Natl Semi Agri in Nineties, Indian Agri Sci, New Delhi, October 23-25, 1991

Mahapatra IC, Bapat SR (1992) Farming system research challenges and opportunities. In: National Sym Resources Management for Sustained Cryp Production, Indian Soc Agron, Rajasthan Agri Univ Bikaner, February 25-28, 1992

Government of India (1989) Report of the Working Group on Agricultural Research and Education for the formulation of Eighth Five Year Plan, Planning Commission, New Delhi

Role of All India Coordinated Crop Improvement Programme, Variety Identification, Release and Notification

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Improved variety is a basic component of refined crop production technology. High input response characteristics of high yielding varieties (HYVs) of wheat and rice transformed the production practices of these crops from traditional low input crop culture to an input intensive crop management system popularly known as green revolution. Introduction of Mexican wheat varieties from CIMMYT and rice varieties from IRRI in (1963-64 and 1965 respectively) for the first time created popular appreciation for the high-yielding improved crop varieties and HYVs became the pass word for increasing the countries food production.

All India Coordinated Crop Improvement Programmes (AICCIPs) organized on different crops or groups of crops (maize, sorghum, millet, wheat, rice, pulses and oilseeds) during 1963 to 1968 represented the national effort to cope with the development and identification of improved crop varieties required for improved production technology in different agro-ecological and socio-economic environments. This presentation discusses the structure, organisation and procedures for identifying improved varieties and their release; and needs, problems and possible direction in future.

Structure of AICCIP

The AICCIPs were developed to involve interdisciplinary research teams in multilocation evaluation of introduced germplasm and breeding lines through out the country on zonal and national levels. Research institutes of the ICAR, State Agricultural Universities (SAUs) and research stations of the state department of agriculture participated in the program by setting up the appropriate research units. The main objectives were: expedite identification of high-yielding widely adapted genotypes for use either as parents in a breeding programme or as varieties in farmers fields; to share the available germplasm and exchange information on its performance under diverse agro-ecological coditions in the country; to train research scientists in uniform multilocation varietal evaluation procedures including screening for diseases and pests, analysis and interpretation of results at the regional and the national levels; to identify region specific crop production problems and varietal requirements and develop suitable approaches for finding solutions; and to produce breeders seed for multiplication and distribution of seed of identified released varieties by the regional (state) seed producing agencies.

Approach and functioning

Initially the main concern was to increase yield potential of the varieties under assured high input conditions and adequately controllable environment through application of irrigation. However,

diseases and pests. The varietal testing programme at the zonal and national level needs to be rationalized and structured keeping in mind the available financial and structural resources. This is possible through optimizing the number of replications, number of sites characterization and choice of sites, and analysing the relationship among test sites. It would require: (1) Climatic classification based on soil and weather analysis, and modeling allowing crop growth and productivity prediction based on probability prediction of weather variables such as rainfall, maximum and minimum temperature, humidity and soil moisture availability (Geographic information system (GIS) analysis is an effective tool for this purpose); and (2) Analysis of varietal response (performance) across locations and relationship among test sites. Also information on occurrence of abiotic and biotic stresses and response characteristics of the varieties would be needed.

The following analytical techniques based on cultivar performance may be mentioned: Estimation of g x e variance component (Horner and Frey 1957); Correlations (Guitard 1960 Hamblin et al.1980); Selection value of test site (Allen et al. 1978, quoted from Miller 1989); Cluster and Pattern analysis (Johanson et al. 1985); Principal Component analysis (Peterson and Pfeiffer 1990); and Mapping of equipotential zones for varietal yield pattern evaluation (Gusmo et al. 1989).

Wide vs. specific adaptation of varieties

AICCIPs during the last 25 years institutional development at the national, zonal and regional levels has reached a stage where development of varieties for specific adaptation can be pursued by the breeding programmes in different parts of the country.

In recent years enthusiasts of on-farm research have advocated development of crop varieties through farmer participatory research (FPR) for specific farm conditions and group of farmers by selecting in early stages in farmers fields (Maurya et al. 1988). Minikits and adaptive trials were initiated to determine farmer acceptability of a new variety, which served the purpose to some extent. To what extent we should carry the concept of specific adaptation and a small target group of farmers need thorough discussion, particularly in the light of seed production and marketing considerations. Normally varieties with a very limited range in adaptation are not a practical proposition, unless performance in that limited range is outstandingly superior and the specific variety is essential.

It goes without saying that zonal or subregional crop breeding programmes need to be encouraged to develop crop varieties for their mandate areas. They should be assisted by the national coordinating unit in effective programme planning, backup with basic information and germplasm; and monitor the progress.

Varietal release, multiplication and distribution

Prior to the organization of AICCIPs release of an improved variety was rather an informal affair. The breeder concerned (economic botanist of the state) identified the superior genotypes and popularised the variety through state demonstration farms and seed was multiplied through registered growers and distributed by the state department of agriculture seed stores. With the advent AICCIP, ICAR and the ministry of agriculture developed the

structure and procedures for the formal release and recommendation of crop varieties at the national level of distribution through NSC, state and agricultural university farms.

Establishment of SAUs with responsibility for agricultural research in the state or regions of the state (where more than one university exist) resulted in development of crop improvement programmes for the region of their mandate. Consequently identification and release of improved varieties at the state and the region level became a common practice.

The procedures followed for the release and recommendation of a crop variety by the central and the state release committees are essentially similar.

1. First year replicated yield trial at the breeders own station.
2. Inclusion of the selected line in the zonal or national IET depending on the availability of seed with the breeder.
3. Inclusion of selected line in URT (uniform regional trial) or UVT (uniform varietal trial at the national level) depending on the availability of seed.
4. Inclusion of the selected line in UVT.

Generally three years evaluation data are considered by the annual workshop conducted by the coordinating unit and the workshop identifies the variety for release at the national level or for certain zones.

The identified varieties are then evaluated in the minikit and adaptive trials for obtaining reaction of farmers and extension workers on the performance and acceptability. After minikit observations the institution responsible for developing the variety submits the proposal for the release of the varieties by the central release committee.

In case the variety does not perform well across the zones at the national level and appears promising at the state level in a zone or a particular region in the state itself, it is extensively tested in the state in regional trials constituted by the institution and in adaptive trials of the institute. Finally if a variety has superior performance than the local check variety, it is proposed for release at the regional level by the state variety release committee. In such releases mostly breeders do not include the varieties available at the national level that have given superior performance in UVT but confine comparison to the local check only. This procedure some times may result in release of a variety in the region which is not necessarily the best available genotype.

For release of a variety it is required to have atleast 10% superiority in yield or should have some special attribute such as disease or pest resistance or quality of the product endowing it with higher profitability or acceptance in the area recommended for it's cultivation than the existing varieties of the area. The three years performance data often come from different set of locations, combined analysis for locations and years is seldom conducted. Under this situation 10% numerical superiority over the existing check does not necessarily ensure higher productivity of the new releases. Moreover comparison with one check cultivar is often fraught with the danger of high g x e interaction and therefore result in chance superiority of proposed variety. Instead it would be desirable to compare the performance of the varieties with the environmental index based on the mean of consistent 4 or 5 check

varieties. An environmental index based on trial mean is not a very good comparison due to changes in the test entries from one year to another.

Despite the release of a large number of varieties in every crop, only a few have reached the farmer or gained his preference. The reasons could be: non availability of seed of the variety due to inefficient multiplication and distribution; not very attractive performance in farmers fields; or not possessing an acceptable quality. In some cases, varieties (eg.Mahsuri) not released by the formal system have become popular.

In recent years some attempts have been made to ensure quick multiplication of the newly released varieties and their distribition such as imposing the requirement of one tonne of seed availability at the time of considering the variety for release. The question of marginal improvement in the performance of the new releases requires to be analysed.

Privte seed companies, seed law and new seed policy

Multiplication and distribution of self pollinating cereal and grain legumes have been mainly confined to governmental agencies such as NSC, SFCI and state seed corporations (SSC). In late sixties a few private seed companies handled production and distribution of hybrid seeds of maize, sorghum, pearl millet, cotton and vegetable crops. However, the requirement of improved seeds in the country is too large for the governmental agencies and a few seed companies to adequately meet the demands.

The new seed policy of the government of India put forward in 1988 is aimed at encouraging the national and international seed companies to take up commercial seed production on a large scale. The important feature of the new seed policy is that it allows and facilitates bulk import and export of seeds of all major crops for commercial purpose. Under the new seed policy domestic seed companies have been provided considerable incentives in terms of low import duty on seeds, seed processing machinery, credit facilities and rebate in income tax. Consequently now there are 300 or more private seed companies operating in different areas of the country. Some of them are in collaboration with large international seed companies, which allow them easy access to the varieties developed by these companies in their international crop breeding set up.

Under the seed law commercial seed producers and traders are allowed to sell any seed under truthful labeling. As such under the present circumstances the question of varietal release recommendation/notification needs a detailed discussion on the following questions.

— Is release and recommendation of a variety by the state or central release committee essential for it's commercial sale?

— Why the decision of releasing commercial distribution of a variety be not guided by it's marketability and acceptance by the farmers and consequently left to the institutions (public or private) responsible for developing the variety?

— What should be the role of the coordinating programme in release of a variety introduced/developed by a private seed company, if official

release is essential at the state and the national level?

— The private seed companies are mainly interested in developing, producing and marketing hybrid seeds. Therefore, what should be the strategy and approach of the coordinating programmes dealing with crops, where hybrid varieties have been established and are popular?

Role of national coordinating unit

A vast institutional development has taken place during the last 25 years, since the initiation of the coordinated crop improvement programmes in terms of SAUs, ICAR institutes on various crops and research and development efforts in private seed industry.

In practice the principal scientists of respective disciplines at the national institute or crop project are designated to act as coordinators at the national level. It means hardly any change in the objectives and the functioning of the national institutes and the coordinated projects, except change of designation of the researchers and financial outlay. In the initial stages of the coordinated programme they had to fill up the institutional gap and therefore had to shoulder the responsibility of developing crop varieties for the different crop growing areas of the country. Often there was an environment of competition between the coordinated project and the upcoming SAU programme. It is time now that the role and objectives are defined in a manner that foster institutional complimentarity instead of rivalry. The main thrust of the national institute should be on disciplinary basic research rather than on development of varieties and their release. In the present situation varietal development and release may be strengthened more and more at the state and the regional level by SAU having the mandate and the private seed companies operating in the area.

The coordinating unit may emphasize on characterization of zones, regions and their requirements. It should assist in programme formulation at the regional level, analysis of the observations (results) at the national level; and compilation of information in the form that it provides guidance for future research.

Issues for consideration

A large number of high-yielding varieties of different crops have been developed during last 30 years. However, rainfed areas which constitute 40-85% of the crop area have shown only a marginal improvement in production due to poor adoption of both improved varieties and crop production technology. The reasons could be: nonavailability of adequate seed of improved varieties;marginal improvement in productivity/ net economic return;and inadequate extension effort.

In order to provide the necessary direction and guidance to the national coordinated programmes to tackle two of the points related to the development and distribution of crop varieties we may consider the following for detailed discussion and necessary action.

1. Development of varieties for specific crop growing environment caused by abiotic and biotic factors. Site characterization, identification of test locations and development of porocedures and approaches.

2. Appropriate seed multiplication and distribution set-up for self pollinated crops of rainfed area. The seed demand structure for the varieties in a region is such that it is commercially not very attractive for the private seed companies. Therefore, most of it will have to be met by public agencies or village cooperatives/ voluntary organizations.

3. Analysis of the reasons for nonadoption of improved varieties and improved technology.

4. Screening for yield. What should be the structure of early and advance generation varietal evaluation to be effective for selecting for yield under adverse growing conditions of the target area on farmer group.

5. Breeding for disease and insect resistance-breeding for disease resistance has been an integral part of any crop breeding programme. Since, diseases have been considered as important yield reducers. The following aspects should receive due consideration:

— Economic threshold for important diseases and level of resistance/ tolerance required in different environments to achieve high yield.

— Relationship between the level of resistance and yield implications in cultivar development.

— Influence of high resistance on pathogen variability implications in developing cultivars.

— Importance of rate reducing partial resistance. Breeding procedures and approaches.

— Multiple resistance based on VR or generalized adaptation and resistance to the predominant diseases/pest complex.

— Identification of areas and components of multiple resistance required.

Conclusions

Long ago, AICCIPS were organised to provide the necessary set up for quick evaluation and identification of HYVs for the different agro-ecological environments, since the crop breeding programmes were not very well developed in many parts of the country. Interdisciplinary research teams at the coordinating centre developed uniform evaluation procedures and provided technical support and training to centres deficient in trained research staff. Major thrust was on developing varieties with high yield potential under high input management in irrigated conditions. The approach has been effective and a large number of varieties have been released during last 25 years. However, the situation under rainfed conditions had not been very encouraging. It appears that selection for yield under highly variable environmental conditions prevailing in the farmers fields has not been effective. For optimizing crop production in a given environment identification of varieties for specific growing environment is essential.

Development of varieties for specific growing conditions requires a detailed characterization of homogeneous regions or target area within the zones and the test sites serving the target region. Also it is essential to improve the efficiency and precision of the varietal evaluation in early as well as at the later stages.

The Coordinated trials in their present form are providing information on general

adaptation of the varieties. The question of wide vs specific adaptation of the varieties needs to be discussed thoroughly in terms of increasing yield and practical considerations of multiplication and distribution of seed by governmental as well as by a growing number of private seed companies. Coordinated trials provide the very basis of release and notification of varieties. However, with the growth of a large number of state and regional research institutions and private seed companies, it may be appropriate to analyze the procedure for varietal release and notification particularly in the light of very liberal seed law and the new seed policy.

It is time now that the role and objectives of the coordinated programme are redefined properly in the light of vast institutional development (research institutes as well as private seed companies) and in a manner that fosters institutional complimentarity at all levels. The main thrust of the national crop research institute should be on disciplinary basic research. Varietal development may be strengthened more and more at the regional level with SAUs having the mandate and the private seed companies operating in the area.

The coordinating unit should emphasize on characterization of zones, regions and their requirements. Assist in program development at the regional level and monitoring and analysis of the programme at the national level for providing direction and guidance for the future research.

REFERENCES

Guitard AA (1960) The use of diallel correlations for determining the relative locational performance of varieties of barley. Can J Plant Sci 40 : 645-657

Gusmo L, Mexia JT, Gomes ML (1989) Mapping of equipotential zones for cultivar yield pattern evaluation. Plant Breed 103 : 293-298

Hamblin J, Fisher HM, Ridings HI (1980) The choice of locality for plant breeding when selecting for high yield and general adaptation. Euphytica 29 : 761-768

Horner TW, Frey KJ (1957) Methods for determining natural areas for oat varietal recommendations Agron J 49 : 313-315

Johansen SB, Teng PS, Bird GW, Grafius E, Nelson D, Rouse DI (1985) Analysis of potato production systems and identification of IPM research needs. Final report of the Potato Task Force, NC-166. Technical Committee on Integrated Pest Management. pp 145

Maurya DM, Bottrall A, Farrington J (1988) Improved livelihoods, genetic diversity and farmer participation; A strategy for rice breeding in rainfed areas of India. Exp Agr 24 : (3): 311-320

Miller JE (1989) Implications of genotype environment interaction. Proc. World Soybean Res Conf 5-9 March, 1989. Buenos Aires, Argentina

Paroda RS, Rai M (undated) Varietal approach for minimizing risk in rainfed agriculture. In Technologies for Minimizing Risk in Rainfed Agriculture. Singh S P, Prasad C.Published by ICAR, New Delhi

Peterson CJ, Pfeifer W H (1990) International Winter wheat evaluation: Relationships among test sites based on cultivar performance. Crop Sci 29 : 276-285

Nucleus and Breeder Seed Production

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In organized agriculture, since inception, seed - the living embryo, was considered as a basic input to agriculture. The farmer always recognised seed as the single well organised carrier of production technology to serve as catalyst for making other agro-inputs productive and cost effective.

Starting with the development of superior materials, in their evaluation, identification, release, notification, multiplication, certification, processing, storage, seed health care and marketing for an effective exploitation in real agricultural transformation, one logically needs to consider all the steps involved to reform the seed production system appropriately.

For a realistic and sustainable varietal development, free access to the world germplasm is a prerequisite. How far that is happening for the benefit of the mankind and how the same is likely to be affected with the stipulations of the "Intellectual Property Regime" in space and time would determine the pace of progress. How far, patenting would affect the use of modern biological tools in solving the unsolved complicated genetic problems would define and determine the growth normal or skewed. Who will produce, what, for whom and finally under what system would depend on the likely course of events in coming decades. nevertheless, an attempt has been made to perceive and put what is likely to be relevant for the nineties. In this endeavour, the existing set-up is presented indicating changes to improve the efficiency of the system.

Seed legislation

Looking to the likely dimension of the Indian seed industry and need for quality control, Government of India enacted the Seeds Act in 1966. The seed rules framed under the Seeds Act were notified in 11968. Based on the experience gained, several amendments were carried out in the Seeds Act and the Rules from time to time. Apart from the Act and Rules and amendments thereto, the Government of India declared seeds as an essential commodity under the Essential Commodity Act 1955, and Seed (Control) Order was issued in 1983. Under the Seeds Act, Central Seed Committee and Central and State Seed Testing Laboratories were established. Powers to notify kind or variety, and fix minimum limits of germination and purity and regulation of sale of seeds were specified. Seed certification mechanism was devised. It included certification of seeds of foreign origin as well. Bye-laws for regulating import and export of seeds were also formulated. Under the Seeds Act, a 'Kind' was defined as "one or more related species or sub-species of crop plants each individually or collectively known by one common name" viz, cabbage, maize, paddy, wheat, etc. Technically, therefore, certificate for genetic purity can be asked for and complied with. However, the practical

relevance of the term 'kind' in the present context needs to be thought of.

As per article 14(1), under the Seeds Rule, 1968, there shall be three classes of certified seed, namely foundation, registered and certified. Foundation seed shall be the progeny of the breeder's seed, or is to be produced from foundation seed which can be clearly traced to breeder's seed. Registered seed shall be the progeny of foundation seed and the certified seed shall be the progeny of registered or foundation seed. As per article 14(2), at the discretion of the certification agency, certified seed may also be the progeny of certified seed provided this reproduction does not exceed three generations and provided further that it is determined by the seed certification agency that the genetic purity will not be significantly altered. Under the circumstances, breeders seed is although not to be certified, it is essentially required to be faithfully produced in order to ensure foundation seed production of minimum genetic purity standards. As such, to ensure high genetic purity of breeder seed, production of nucleus or basic seed may be essential. This may be produced by raising individual plant/panicle/spike progenies.

If seed multiplication ratio is not very low, as in potato or groundnut, then the normal nucleus, breeder, foundation and certified seed production chain could be followed. This would require a minimum five years of advance planning. How far is this happening? If not, how long should we depend on adhoc contingency plans? Often points were raised to bring breeder seeds under the purview of seed certification but the same was not considered desirable as it would further delay the availability of certified seeds to the farmers. Further, no one else could be a better judge of the genetic purity than the breeder himself. Nevertheless, effective monitoring of breeder seed is considered essential.

Varietal development

India has the distinction of developing hybrids in pearlmillet, cotton, castor and pigeonpea for the first time in the world. Due to concerted coordinated research efforts, 1937 varieties have been notified for commercial cultivation in the country (Table-1). Of these, 94 varieties are denotified and technically, therefore, 1843 varieties continue to be eligible for certified seed production. Nevertheless, on an average, about 800 varieties are in use for organised seed production whose breeder seed is essentially required to be produced.

Table 1. Varieties notified under the Seeds Act by February 1992

Crop Commodity	No. of varieties
Rice	352
Wheat	154
Sorghum	92
Maize	82
Pearlmillet	58
Other Cereals and Small Millets	109
Pulses	308
Oilseeds	264
Forages	72
Fibre crops	140
Vegetables	306
Total	1937

A number of improved varieties once taken to the farmers have proved their worth and have enhanced productivity substantially. Many a time, genetic potential is established to almost four times than that of State/National average yields. It is amply demonstrated that 20-25% enhanced yield could be realised by replacing the obsolete varieties with the quality seeds of improved

Table 2. Number of varieties notified and quantity of breeder seed produced during 1987-88 to 1990-91

Crops	Quality (kg) of Breeders seed produced in different varieties										
	1987-88		1988-89		1989-90		1990-91		Total		%
	No	Kg	No.	kg	No.	kg	No.	kg	No.	kg	of total seed
Rice	6	140	10	2660	42	34878	7	21525	65	59203	12.12
Wheat	2	13343	4	20269	9	83502	2	87936	17	205050	8.91
Maize	2	200	11	5500	0	10378	0	2375	13	18453	17.90
Sorghum	2	0	2	0	1	310	0	0	5	310	0.52
Pearl-millet	2	376	2	557	2	200	2	0	8	1133	4.60
Cotton	2	9430	3	7595	7	7860	1	7127	13	32012	31.46
Pulses	10	90	9	26070	9	28820	7	31530	35	87320	7.61
Oil-seeds	14	14354	10	14518	9	62559	6	36622	39	128053	4.43
Fodder Crops	3	0	2	22	5	0	4	200	14	222	0.21

varieties. Despite the fact that the pace of varietal development in the last 4 years has been appreciable, their use as evidenced by the breeder seed produced has been rather poor (Table 2). Nevertheless, there are a number of areas such as drought-prone, salt affected and hilly areas where further concerted efforts are required. In general, varieties with better resistance to various abiotic and biotic stresses are to be developed and quality attributes need to receive pointed attention.

Nearly 99% of the notified varieties are contributions of the public sector. Of late, the private sector has shown keen interest in getting their materials evaluated, released and notified. In general, multilocation trials for 3 years are required before varieties are identified by the respective crop workshops for release and notification. Nevertheless, under the new seed development policy of 1988, only one season testing at 15-20 locations is essential before a variety of foreign origin is considered for provisional notification. Till date, 2 sunflower hybrids are provisionally notified under this policy. An additional testing for 2 years is essential if regular notification is to be sought for. However, vegetables, flowers and ornamental plants are kept under Open General Licence (OGL) where testing is not required and one can continue importing and selling seeds without evaluation, release and notification.

Seed technology research and seed production system

Organised research was initiated in 1979 with the establishment of 14 centrs in different State Agricultural Universities (SAUs) with multidisciplinary teams involving 49 scientific, 66 technical and 31 administrative/supporting staff. A coordinated research programme on Seed-borne diseases at 8 SAUs and IARI, New Delhi was also initiated in 1979 with 9

scientific and 18 technical personnel. However, after realising the fact that seed health is invariably looked into the seed research project, the project on seed-borne diseases was merged and is functioning as an integral part of the National Seed Project with effect from April, 1991. An UNDP assisted Centre of Excellence on Seed Technology was also established at HAU, Hissar. In 1988, a separate Seed section was created at the ICAR Headquarters to deal with all aspects pertaining to seed research and production. For discharging statutory functions, a Central Seed Testing Laboratory was established temporarily at IARI, New Delhi.

There are 38 breeder seed production units of field crops and 11 of vegetable crops located in various SAUs and ICAR Institutes. Presently, there are 64 scientific and 85 technical positions in these institutions under the programme. In addition, separate units for the production of breeder seed of groundnut, sunflower and soyabean have been established at 24 centres with 44 scientific, 101 technical and 16 administration/supporting staff with the funds provided under Oilseeds Production Programme of Technology Mission on Oilseeds. In this programme, seeds are supplied to the indenting agencies free of cost for which seed cost on actual supply basis is disbursed to the centres out of the funds provided by the Mission. Under pulses development programme, although no staff component is provided, similar seed cost disbursement is made. Oilseeds and pulses programmes put together cost about rupees three crores per annum. Under Special Foodgrain Production Programme,a revolving fund to the tune of Rs.50 lakhs has been provided for breeder seed production of wheat, rice, chickpea, pigeonpea and maize. In a separate project on Promotion of Hybrid Research and development in Selected Crops, an additional amount of Rs.172 lakhs is also provided for undertaking seed production of nine mandate crops. Efforts have been made to suitably equip these units in terms of manpower, mobility, field and laboratory facilities. Further, cold storage modules are provided for each of the crops/commodities for storage of breeder seed and working germplasm on a limited scale, with Project Directors/Coordinators under NSP/Hybrid Project on selected crops/Indo-UK collaborative Project. Further, processing and cold storage facilities are created at major seed producing centres.

With a view to provide quality seed to the farmers, National Seed Corporation (NSC) was established in 1963 at the central level. Subsequently, in 1969, State Farms Corporation of India (SFCI) under the central sector came into existence. Later, an urgent need for the establishment of seed corporations in each of the States was felt and 13 Seed Corporations (in Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Karnataka, Maharashtra, Madhya Pradesh, Orissa, Punjab, Rajasthan, Uttar Pradesh and West Bengal) were set up by the end of the 7th Five year Plan. Their working facilities are being further improved through World Bank Funded Project (NSP III) which is in operation with effect from 1990.

Apart from crop-based Institutes, national Research Centre, Project Directorates and SAUs; the NSC and SFCI are also vested with the mandate of production of breeder seed. In states, SAUs also produce some quantities of foundation seeds. The certified seed production programme is organised at the farmers fields by various seed corporations. As the Government of India does not differentiate between the public and private sectors in supply of the breeder seed, private seed

companies are also involved in the production of foundation and certified seeds of public bred varieties besides their own varieties.

Vertical seed replacement and breeder seed requirement

The quality of seed available with the farmers, merit of the new variety, capacity of the farmer to purchase fresh seed, availability of new seeds, cost and finally the likely return on investment determines the seed replacement year after year. It has been amply demonstrated that about 10% increase in yield could be had if certified seed in place of local seed is used. It is, therefore, imperative that availability of certified seed is assured for enhancing productivity and production.

In projecting the seed requirements, various States and Central Government have kept a target of seed replacement varying from 10-100% in different crops. The seed replacement rate contemplated in strictly self-pollinated crops are obviously kept low as most of the seed spreads horizontally. In this group of autogamous crops, the vertical seed replacement rate is also determined based on the quantity of seed required per ha. In those crops where seed requirement per ha is low, vertical seed replacements are generally high. Scientifically, the potential of available varieties and degree of cross-pollination leading to deterioration of genetic purity should precisely determine the targeting of replacement.

Although, potential hybrids in many crops are available, due to poor seed availability, area under hybrids is far below the expected coverage. The projections made by the Government of India for the 7th plan on hybrids is also low probably due to the present low seed production of hybrid. Every effort should be made to ensure that the maximum area is brought under hybrids in shortest possible time. A projection has been made for both self and cross pollinated crops (Table 3).

Strategy for achieving seed Production tarrgets

The greatest impediment in the seed sector is the poor conversion of breeder seed to foundation seed and in turn to certified seed. In almost all the presentations, certified and truthful labelled seeds are put together. The so-called truthful labelled seed is not even procured from the reliable sources. As such, its very basic quality is always questionable.

A detailed plan for achieving seed production targets is discussed hereunder:

Ensure timely awareness

Once the varieties are identified by the Workshop, test stock seed must be produced to help on farm trials and an early popularisation of newly identified varieties. The SFCI may produce the seeds of national varieties whereas the seed of state varieties can be produced by the respective State Seeds Corporations. Government of India as well as respective State Governments must keep a close liaison to ensure that the test stock seed reaches the farmers along with the associated technology capsule to generate awareness about the merit of different varieties. The system must have an effective inbuilt mechanism of feedback to ascertain as to how the variety has performed under real farm situations. Further, as a follow up, once the variety is released, minikit programmes must be implemented in letter and spirit. Quite often programmes are undertaken without

Table 3. Estimated requirement of certified seed during 1995-96 to achieve projected vertical replacement rate

Crop	Area (Lakh in 1990-91)	Seed rate (kg/ha)	Seed Multiplication ratio	Projected vertical seed replacement (%)		Breeder seed (kg)	Foundation seed (kg)	Certified seed (kg)
Wheat	239.77	100	1 : 20	10		599425	11988500	2398
Paddy	425.96	30	1 : 80	15		29950	2396025	1917
Maize (variety for 80% area)	59.54	20	1 : 100	15		1429	142896	143
Hybrid (for 20%area)		20	1 : 100	100	F	2382	238160	238
					M	1191	119080	
Sorghum (Variety for 75% area	144.97	12	1 : 100	15		1957	195696	196
Hybrid (for 25%area)		12	1 : 100	100	*A*	4349	434880	435
					B	2174	217440	
					R	2174	217440	
Pearlmillet (variety for 70% area)	104.47	4	1 : 200	33		241	48259	97
Hybrid (for 30%area)		4	1 : 200	100	A	313	62680	125
					B	157	31340	
					R	156	31340	
Finger millet	21.77	5	1 : 80	10		170	136006	11
Chickpea*	74.1	75	1 : 10	8		444600	4446000	445
Lentil	10.53	40	1 : 30	10		4680	140400	42
Pea	4.71	60	1 : 10	10		28260	282600	28
Greengram	29.85	20	1 : 40	12		4478	179100	72
Blackgram	31.82	20	1 : 40	12		4373	190920	76
Pigeonpea	36.15	20	1 : 100	15		1085	108450	108
Groundnut*	82.97	150	1 : 8	5		972305	7778438	622
Rapeseed & Mustard	57.22	5	1 : 150	35		445	66757	100
Soybean	23.63	65	1 : 16	12		72059	1152938	184
Sunflower variety (for 60% area)	16.42	10	1 : 50	20		788	39400	20
Hybrid (for 40% area)		10	1 : 50	100	A	2624	131200	66
					B	*1312*	*65600*	
					C	1312	65600	
Linseed	11.48	25	1 : 30	10		3189	95667	29
Castor variety (for 80% area)	8.07	12	1 : 60	10		215	12900	8
Hybrid(for 20% area)		12	1 : 60	100		537	32200	19
Safflower	8.21	12	1 : 60	15		411	24630	15
Sesame	25.95	5	1 : 150	15		87	12975	19
Cotton variety (for 90% area)	73.96	20	1 : 50	15		7987	399360	200
Hybrid (for 10% area)		20	1 : 50	100	F	5912	295600	148
					M	2956	147800	
Jute	7.78	10	1 : 100	50		389	38900	39
Total 1499.35						2206469	318844776	7800

A = A line; B = Baline; R = Restorer; F = Female; M = Male; *When only one stage of foundation seed production is considered instead of two stages which is appropriate for such crops

ascertaining what is required to be distributed and whether adequate quantity of seed is available or not. As such, minikit programmes must be planned based on the availability of seed of the right kind of variety lest the very basic purpose of minikit distribution would be defeated. It would be worthwhile to identify suitable agencies for seed production and in turn its distribution to make the system dynamic. Even the private sector may be involved. This may include seed production and distribution on contractual basis through identified agencies. Supply of treated seeds in small packets may be considered. For example, seed for 0.4 ha of newly released varieties may be supplied to head of panchayat of each village.

Frontline demonstrations on a limited scale through the ICAR system should also form an integral part of the overall strategy so that the potential of the material is established and demand of seed is generated in the shortest possible time. Seed Corporations must also, as a promotional activity undertake such demonstrations similar to Fertilizer Corporations. On an experimental basis, ICAR/Govt. of India/State Governments may also develop some kind of memorandum of understanding as a supplementary strategy with private sector where exclusive right for sale of a particular variety may be given to specific private company. Under such a situation, right for sale of seed of a variety may be auctioned. The government agency may, however, have the right to intervene only when the seed is not supplied as per the requirements.

Formulate rolling plan

Advance seed production plans must be formulated. As new varieties are released and notified year after year, a plan on a fixed model would certainly not be rational. As such, a rolling plan in advance, statewise, cropwise and varietywise must be formulated for five years and be subjected to review each year to provide for introduction of new varieties and replacement of obsolete. In such a plan, the seed programme envisaged in the previous year, would continue to be to the tune of about 90 per cent. As such, nucleus seed production programmes could be continued every year for about 90% of the varieties well in advance and on sound scientific footing.

Operate through single window

After indents are received, the production is by and large, undertaken by respective breeders. This adds to their work, leads to disintegration of the basic objective, brings down the efficiency of the whole system, ultimately defeating the very basic idea of the establishment of separate seed production units under the National Seed Production (NSP). In many institutions, seeds are produced at 20 or more locations resulting in a number of problems with regard to production, procurement, processing, storage and supply. It is, therefore, imperative that a single window system of working is adopted where the seed production programmes are undertaken by the NSP staff who must have complete control of the nodal and need based sattelite farms, seed processing plants, storage godowns and seed supply system. The responsibility of respective breeders should be restricted at the most to need based visits, as and when asked for, in ascertaining the genetic purity. Nevertheless, the responsibility for production of nucleus/basic seed must continue to be vested fully with the respective breeders.

Under the single window system of working, the status of the Incharge, must be that of a Professor who may be designated as Associate Director (Seed Production). The farm must be fully irrigated and should have field mechanisation commensurate with the requirements. The seed technology research units, wherever located, should be under the same command so as to have greater liaison and need based scientific support and feedback for meaningful research and seed production.

Create revolving fund institutionwise

For undertaking production, availability of funds on a sustainable basis in advance is imperative. Many a time funds are not provided in time and once the seed is supplied/sold, sale proceeds go as receipt in the general pool. As such, availability of funds continue to be a perpetual problem in undertaking seed production. Under the circumstances, it is absolutely essential that a revolving fund commensurate with the seed production requirements are created and kept at the disposal of the Incharge of the single window system of working. The sale proceeds of seed must be ploughed back to the revolving fund account so as to enable undertaking the programmes year after year. The amount of receipts in excess of the provided revolving fund should be left at the discretion of the incharge of the single window system and the institution so that they can, through their best can have additional resources for augmenting facilities for further increasing their capabilities for production of breeder seed. Incharge must also be vested with the maximum flexibility in decision making. This would make the system cost effective, accountable, sustainable and result-oriented.

Revolving fund provided for various programmes *viz.* Special Food Grain Production Programme, Hybrid Project in Selected Crops etc. be augmented and the system of payment of breeder seed for oilseeds and pulses from the grant received from DAC, GOI be changed. Instead of this grant being provided annually, a onetime investment as revolving fund would be highly desirable. It is felt that cropwise revolving funds are not likely to pay dividends. As such, it is imperative that institutionwise revolving fund based on their actual requirements are created. In this excercise, all the revolving funds provided under different schemes need to be merged and need based additions are made by ICAR so as to make it a onetime investment programme for each producing agency. Such a system can make this programme develop on a sound scientific footing.

Think of cost effectiveness and arrest proliferation of centres

For quality breeder seed production, high quality nucleus seed stock is essential. Nucleus seed production, must therefore, be under the direct control and supervision of the breeder who must ensure adequate production. For undertaking adequate quantity of nucleus seed production, advance indenting as per calender of operation, is imperative (Table-4). The seeds thus produced, should be supplied to the incharge of the single window system who in turn should organise breeder seed production. The production is required to be restricted to a minimum number of centres in view of their efficiency in production, monitoring and handling. Presently, breeder seed production units are created in almost each University/Institute. It needs to be ascertained whether these units are cost effective. If not, ways

Table 4. Calender of operations for production and distribution of breeder seed

Steps	Last date by which the action is to be completed	
	kharif	rabi
1. Placement of Indent of Breeder Seed with Directors of Agriculture / Horticulture / Animal Husbandary by the concerned seed producing agencies in the State (Central Agencies such as NSC, SFCI etc. would place their indents directly to the DC (seeds) Ministry of Agriculture, Govt. of India	1st week of January for both the seasons at least one season in advance to ensure nucleus seed production	
2. Communication of the screened and compiled indents by Directors of Agriculture / Horticulture / Animal Husbandary of the State to DC (Seeds), Ministry of Agriculture, Govt. of India	3rd week of January for both the seasons	
3. Communication of compiled indents by DC(seeds), Ministry of Agriculture, Govt. of India to the ADG(Seeds), ICAR and concerned PD/PC.	15th March	15th July
4. Communication of Breeder Seed Production Plan in BSP-1 by the concerned PD/PC to all those mentioned in BSP-1	15th May	15th October
5. Deposit of 25% of the cost of breeder seed as advance by the indenting agencies with the concerned universities/institution to whom the programme has been allocated as per BSP-1	30th May	30th October
6. Communication of the BSP-2 by the concerned breeder to all concerned	15 d after actual planting breeder seed crop	
7. Communication of the BSP 3 by the concerned breeder to all concerned	15 d after actual inspection of breeder seed crop by Joint Monitering Team	
8. Communication of the final production figures of breeder seed by the breeder in BSP-4 to all concerned	15th February	31st July
9. Communication of the result of the grow out test on BSP-5 (formarally BSP-4) by crop Coordinator to the DC (seed) and other concerned persons (dates etc. to be decided)		
10. Communication of the allocation of breeder seed by DC (seeds) Ministry of Agriculture, Government of India, to Director of Agriculture / Horticulture / Animal Husbandary / concerned indentor / producing breeders	31st March	15th October
11. Communication of breeder seed distribution by producing breeder vide BSP-6 to all concerned	45 d after issue of the allotment letter by DC (seed)	
12. Utilization of breeder seed for production of F.S. to be provided by DC (seeds) vide BSP-7	End of February	End of July

and means are required to be identified to make them economically viable and sustainable.

Exclusive breeder seed production centres with a mechanism of 'switch on' and 'switch off' in potential pockets cutting across institutes and universities may be established in selected zones. These centres may be identified based on their potential of production of breeder seed of different crops in climatically variable seasons. Such a system in appropriate form would certainly be cost effective in terms of production, monitoring, processing, storage and supply. Nevertheless, a view is to be taken on the infrastructure already created, and this would require to be dismantled once concerted and integrated production programmes on selected locations are conceived and implemented. Looking to the structure in each State and Institute, production of seed of a particular set of varieties to meet the state requirements with existing infrastructure may be continued. But, it would be imperative to consider what is the minimum quantity and of what kind, to make the unit economically viable and sustainable. Also in such a situation, it is quite likely that a mandate on foundation seed production commensurate with the excess infrastructure is allowed, and seed required for undertaking frontline demonstrations are also agreed to. This vital issue would require a very careful consideration.

Provide funds for breeder seed monitoring

To begin with, NSC was the only user of breeder seed. Hence, limited monitoring of breeder seed plots was done through NSC out of their own resources. Presently, as the breeder seed is also utilised by various State Seed Corporations, SFCI and private sector seed companies, NSC is logically reluctant to arrange monitoring with their own resources. It is, therefore, essential that the nodal seed department i.e. Department of Agriculture and Cooperation, GOI who have the responsibility for quality seed production and where breeder seed is used as an essential input, should consider an initial grant of Rs.30 lakhs in the first year. The fund could be kept at the disposal of NSC who in turn could organise monitoring involving one of their own staff, the concerned Breeder, a representative of the respective State Seed Certification Agency and Project Director/Project Coordinator or his nominee. The TA/DA of the monitoring team could be disbursed out of this fund, and based on the actual expenditure the fund should be recouped each year. About 5% of the total expenditure could be charged out of the fund by NSC as their service charges. The seed once rejected by the Committee should not be allocated for foundation seed production. It is, therefore, imperative that genetic purity standards for breeder seed need to be self imposed. These must be higher than those considered for foundation seed. No compromise on genetic purity should be made.

Have off season facilities for grow out test

To ascertain precisely the genetic purity a system must be developed to get the genetic purity tested through grown out test without disrupting subsequent seed production chain and fulfilment of timely needs. A well thought of, off season nursery facilities for grow out test needs to be created and the results made available in time to produce/certify foundation seed. These facilities must be under the direct control of ICAR cutting across crop and commodities.

A tie-up can be had with off season nursery facilities which are presently in a fragmented form for multiplying promising breeding materials for different crops.

Ensure lifting and buffer stock

Each indentor must deposit with the producing institution 25% of the cost of the seed based on the prevailing cost. It could be adjusted once the seed is lifted. In the event of nonlifting of seed, the advance money should get automatically forfeited. This is essential as almost 50% of the breeder seed produced in a number of crops remains unlifted despite having firm indents, thereby leading to considerable loss of time, resources and valuable seed. Buffer stocking of seed needs to be implemented as an ex-ante decision to ensure that the seed which is indented but not lifted is kept in the buffer stock. Similarly, the seeds of new varieties have to be produced, even if there is no indent as a calculated risk to form a part of the urgent use/buffer stock. For such a venture, which is essentially required for aiming at sustainable agriculture, the Government of India, through its nodal department, must bear the cost of such a buffer stock. Buffer stocking can be thought of at regional basis in view of its cost effectiveness.

Ensure effective conversion and feed back

Effective conversion of breeder to foundation seed is imperative. Nevertheless, seed production at foundation and certified seed stages are far below than expectation in terms of actual quantity of breeder seed received vis-a-vis foundation and certified seed produced. Under the circumstances, it would be necessary for the nodal department to ascertain precisely and ensure that the seed is put to effective seed production chain. The very basic philosophy of receiving indents through Seeds Division, DAC, GOI is that the same nodal department would monitor production of foundation and certified seed. Effective ways and means are, therefore, required to be worked out lest the very basic purpose of breeder seed production would be defeated.

Have manpower trained

To bring uniformity in quality nucleus and breeder seed production, it is essential to formulate common production strategies to ensure genetic purity. It would, therefore, be desirable to deliberate basic issues involving production, processing, bagging, tagging and storage-cutting across crop, commodities, projects and programmes. Based on the strategies, each breeder/unit must ensure production. The technical staff involved must undergo a one week need based training course to update his knowledge and skill for ensuring effective seed production. In this endeavour, greater interaction between NSP and AICCIPs is essential.

Think of incentives

All said and done, where research papers count, how can one think of excellence unless ways and means are thought of to ensure that producing breeders are assured of their merit promotions based on production targets vis-a-vis performance. To start with, as an incentive, why can't we think of sharing of the profit beginning with an insignificant level of less than 5% or 50% of the basic pay whichever is less.

Involvement of Private Sector in Improvement, Testing and Release of Varieties

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Private sector participation in the improvement, testing and release of varieties was virtually nonexistent in 1957 when the Indian Council of Agricultural Research (ICAR), in collaboration with the Rockefeller Foundation, undertook the first All India Coordinated Maize Improvement Project. That project was subsequently extended to Sorghum and Pearl Millet in the mid-1960's. This was followed by similar projects on different crops and group of crops. Now that the role of the private sector in crop improvement is expected to increase significantly, its involvement in national research activities needs to be ensured.

Prior to 1988, there was a rather limited activity by the private sector in the seed industry in India. The public sector accounted for more than 70% of the total turn over of approximately US$100 million leaving the remaining to private sector. Further, crop breeding research was primarily conducted in the public sector. In the private sector, breeding was limited to just 3 or 4 companies.

With the Government's "New Seed Policy" announced in 1988, many new national and multinational private sector companies, have entered the seed business. The new comers are well recognized and respected, including: ITC, Sandoz, Cargil, Hoechst, Ciba-Giegy, ICI, SPIC, Bejo, Hindustan Lever, Harrisons Malayalam, JK Seeds, and a host of others. For policy makers in government there is a lesson to be learned from this phenomenon. namely, even slight deregulation of the sort introduced in 1988, can spur enoromous development in the country's seed industry. For the time being therefore, the great strides that have been made since the introduction of the "New Seed Policy" should not be jeopardized by any new regulations.

Because of this surge of activity, we believe the time is right to involve the private sector in the discussions on the improvement, testing and release of varieties, and on other topics which can affect the development of the seed industry. We therefore take this opportunity to congratulate the organizers of this meeting for including private sector representatives in these important discussions.

Basically, there are two types of seed companies in the private sector in india.

- The first group comprises those companies which produce and market public varieties and hybrids, and have no or limited research and development (R&D) activities of thier own. These companies can be compared to the National and State Seed Corporations in the public sector. There are several such companies, but only a few have a national stature.

- The second group comprises of companies with their own R&D activities and which are engaged in crop improvement research. These few companies produce and market proprietary hybrids and varieties. Research by some of the leading companies is "Recognized" by the Departments of Science and Technology; they are therefore well placed to play an important role in national research efforts aimed at genetic improvement of crops. They can be catalysts for the development of the seed industry in the country.

In fact, if the present trend of private seed sector participation continues, the role of the private sector is likely to become increasingly important in the future.

Intellectual property rights and the role of private sector in plant improvement

The private sector, both national and multinational, can play an important role in plant breeding research. In developed countries, particularly in North America and Western Europe, this role is already shifting rapidly from the public to the private sector. The public sector is moving more towards basic research on germplasm improvement, biotechnology, and seed enhancement research. This shift, to a great extent, is a result of the enactment of Intellectual Property Rights (IPR).

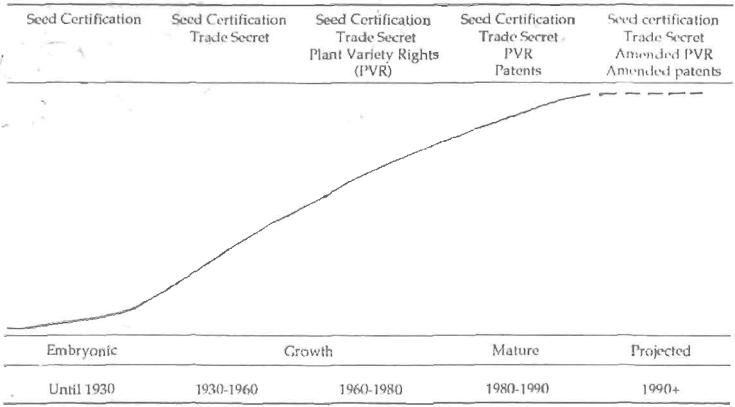
In India, Plant Variety Rights (PVR), and other Intellectual Property Rights, covering plants, genes, etc., do not exist. The seed industry itself is in the embryonic stage of development. Adopting IPR laws in India is more likely to stifle growth in the seed industry, than accelerate its development. Moreover, when the skilled personnel and specialized institutions required to implement such laws are inadequate, their enactment is of little value; it leads only to more bureaucracy.

We should keep in mind that the end of any responsible seed policy is to ensure that elite seed is made available to farmers, as and when needed. Legislation that hinders that objective is counter productive. The lesson of 1988 and the New Seed Policy is that when it comes to regulation, "less means more".

Developing countries, including India, are in need of transfer of know-how. Their seed businesses will only be able to develop and grow if there is appropriate transfer and absorption of technology from the industrialized countries. Consequently, legislation should promote such transfer, rather than promulgate sophisticated IPR, which are ill-adapted to the technology level of this country.

Historically, the seed industry in developed countries has expanded by developing and selling hybrids (Table 1). Nearly 40% of the total global commercial seed business of approximately US $ 15 billion is accounted for by sales of hybrids of various crop species. The seed industry generally shifts rapidly towards hybrids whenever they are technically and economically feasible. The point is that with hybrids, breeders can achieve the equivalent of intellectual property protection. They do so by keeping secret the parent lines required to produce the hybrid. With proper incentives, the private sector can become a dynamic force in hybrid seed development without the burden of IPR legislation. For its part, the public sector is best placed to continue varietal improvement research.

Table 1. Historical representation of seed industry development in developed countries and type of protection available



In fact, most recent catalogues of multinational vegetable seed companies are almost entirely composed of hybrids. Despite the fact that hybrid technology has actually been available in several developing countries for decades, there has been minimal investment by the private sector in plant breeding research in those countries. This further suggests that enacting IPR laws at this stage of the seed industry's evolution in developing countries, will not necessarily lead to investment in plant breeding research by the private sector.

The private sector wants to recover the value it invests. This can be done through hybrids; IPR legislation is neither necessary nor desirable. The recent surge of activity by the private sector in the Indian seed industry indictes that there is ample business opportunity in hybrids. Hybrids enable seed companies to obtain a return on their investment either directly in the form of gross margins, or indirectly in the form of royalties, or both. The crops involved include ones for which hybrids are already available, such as corn, sorghum, rice, millet, sunflower, sugarbeet, cotton and several species of vegetables (Table 2).

Although we are firm supporters of IPR laws in the developed countries where the seed business is a mature industry, we believe it is premature to introduce such laws in developing countries, like India. The seed industry rather needs deregulation of some existing seed and quarantine laws, and removal of tariff and nontariff trade barriers. When the seed industry enters the growth phase and matures as an industry, IPR laws will indeed help to protect the rights of breeders and provide further stimulus for growth and development.

If IPR is not the answer, which we understand is contrary to the opinion of

Table 2 The currently available hybrid systems and some selected examples

Hybrid system	Crops
Manual or Mechanical Emasculation	Corn, Cotton
Growth regulators (Gibberellins, $AgNO_3$, Ethrel, etc.)	Cucumber, Melon
Cytoplasmic male sterility (CMS)	Sorghum, Rice, Millet, Sunflower
Self incompatibility (SI)	Cabbage, Broccoli
Natural Genetic male sterility (ms ms)	Pigeon, Peas
Engineered genetic male sterility	Oilseed-Rape

some leading international experts, then what would it take to involve the private sector in plant improvement research? To repeat, we maintain that hybrids, elite varieties and further deregulation of the seed industry is the answer; the movement into India of the world's major seed companies since 1988 is their de facto acknowledgement of this.

This trend can be further encouraged by:

- Continuation of the policy of truthfully labelled seed;
- Keeping identification, notification and registration of hybrids optional;
- No compulsory seed certification;
- No preferential treatment by government agencies for certified seed as opposed to truthfully labelled seed;
- No lid on seed pricing and its compulsory declaration on the seed bag or tag; and
- Further easing of quarantine laws for germplasm imports.

Role of private sector in testing and release

Present constraints

Some serious constraints on the efficient functioning of coordinated projects are discussed.

- The number of entries a breeder is permitted to contribute to the Initial Evaluation Trial (IET) is restricted to one or at the most two entries. Even if the breeder can contribute some outstanding entries, he is not permitted to do so. Based on multilocation test data, even if a new variety or hybrid outyields the standard checks by a significant margin, while having all the desirable attributes, it still cannot be included in the IET. This restriction needs to be overcome.
- The constitution of the Variety Identification Committee varies considerably for different projects. Whereas, eminent breeders and scientists are invited as members for some projects, for others the project coordinator and his associates decide this important issue. We even question the desirability of having identification committee - is it necessary. Can it not be eliminated?

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- The identification of a variety or hybrid in a workshop is often done in the absence of the concerned breeder. In other words, the breeder is not given an opportunity to present and defend the data regarding the entry which he has developed with a specific objective. Likewise, he is not given a chance to present his entry before the Variety Release Committee. If the process of "identification" is to continue through a committee, it is important to invite the breeder of the variety or hybrid to the committee to defend his entry.

- In some projects, the private sector breeder is required to part with the parent seed of the hybrid as a pre-requisite for entry to IET. Parent lines of hybrids are proprietary products of considerable value. Is it necessary to insist private breeders to provide confidential information about parent inbreds, or to part with their seed?

- Quality of field experimentation techniques at some coordination centres is not sufficient; the result of which is that the coefficient of variance (CV) is very high and data are not reliable. This creates unnecessary cost and waste. Efforts need to be made to set strict requirements for field plot techniques and to enforce them.

- There are no fixed and clear cut guidelines governing the release of a hybrid or variety. This sometimes results in failure of release of some promising and elite genotypes. The guidelines must be clearly defined and equitably applied. Clear guidelines would make the need for committees even less critical.

Possible solutions

Besides making the testing and release system simple and quick, it is important to treat the promising genotypes on the basis of their performance merit. The following are some suggestions to overcome the constraints discussed above:

- If the breeder has already tested his entries in his own trials against the standard national checks at the required number of locations for the specified number of years, and if his new hybrids or varieties outyield the checks by a certain margin, he should be permitted to submit them as entries in IET. To restrict the total number of entries, a submission fee per entry could be charged to the participants. This would not only restrict the number of entries but also encourage the breeders to submit only elite candidates. We know that the suggestion is not going to be welcomed by public or private sector breeders, but we believe it merits serious consideration.

- There needs to be an uniformity in the constitution of various variety and hybrid identification committees across different projects. If those committees are to continue, then at least some eminent scientist(s), and perhaps one or more private breeders, should be included along with the project coordinator.

- The breeder should be given an opportunity to defend his entry. He should be provided with an opportunity to present the data

pertaining to his entry before the Variety Release Committee.

- Through hybrids, breeders can achieve the equivalent of intellectual property protection. In the absence of IPR in India, no breeder should be required to divulge confidential information pertaining to the parental lines, or part with the parent seed.

- The centres reporting poor quality and unreliable data with high CV should be identified. The concerned centres should be removed from the trial network if they fail to meet minimum standards.

- A close monitoring is required for maintaining uniform standards of field plot techniques. Project coordinators should encourage visits of private and public sector breeders to test sites to see the trials. The visitors may send the report of their observations on the quality of trials to the coordinator and this report may be considered while compiling the data. If possible, this report may be presented in the annual workshop as well. The participation in the All India Coordinated Network should be a privilege rather than an obligation. Somehow this attitude needs to be cultivated.

- Distinct and well defined guidelines should be fixed for the release of a new hybrid or variety. These guidelines should be circulated among breeders to help them decide whether or not to submit a variety or hybrid to the All India Coordinated Trials.

- The private sector should be encouraged to provide testing locations which they must have in different agroclimatic zones. Since in certain zones the available locations for testing in the public sector are limited, this is very important.

- Competition among testing centres, including those of the private sector, in the quality of experimentation can be encouraged so that it leads to improved overall techniques. Visits to outstanding trials by both public and private breeders should be encouraged. Such visits are likely to motivate them to improve the quality of their own experimentation.

Conclusions

The private sector can play a significant role in getting new improved cultivars to the farmers quickly and efficiently. In formulating national seed policies, the following goals should be considered:

- Without IPR, the private sector will be more attracted towards research on hybrids than on open pollinated varieties. It is in the interest of the nation to let this shift take place, rather than waste resources enacting complicated IPR legislation to attract the private sector to do variety research.

- The overall goal should be to get the improved cultivars to the farmers as quickly as possible. Lengthy and complicated procedures for identification, notification and registration need to be avoided. Notification of the variety should be

kept optional and should not be made compulsory.

- Compulsory certification should be avoided in the interest of expediency. We strongly believe that a private company might be able to sell a bad product once but not repeatedly. To stay in business in the long term, high quality products will have to be provided to the customers. The "fly by night" companies normally disappear quickly. Legislation should focus on how to attract serious companies, rather than becoming a watch-dog for a few bad ones.

- The private sector can become an ally in the overall seed industry development, and should not be considered as an adversary.

- Some legislation is necessary and unavoidable but we must remember that regulations increase costs. Increased costs deter private sector investment. The goal should be to pull the private sector in rather than letting them stay away.

Last, but not least, let the public and private sectors become partners in progress in the interest of the nation, rather than continuing to look at each other with mistrust.

New Technologies for Testing Varietal Identity and Purity

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Variety identification is becoming increasingly important in the operation of modern crop production. All sectors of the seeds - from plant breeders through the variety and seed testing authorities, the certification agencies, seed merchants, farmers and ultimately to the grain buyers, processors and consumers - benefit from the ability to assess varietal identity and purity. Until fairly recently, such identification could only be carried out by what could be called a classical taxonomic approach. This involves the detailed observation of seeds and/or growing plants and the measuring, recording and analysis of a range of morphological characters (descriptors). In practice, this is an extremely successful process, largely forming the basis, for instance, for procedures for distinctness testing of new varieties. However, it can be a time consuming operation requiring large areas of land, replicated trial plots and highly skilled personnel making often quite subjective decisions. Also, many of the morphological descriptors used are multigenic, quantitative or continuous characters, the expression of which is altered by environmental factors and the analysis of which requires statistical tests. There are thus compelling reasons to find more rapid and perhaps cost-effective procedures which could augment this morphologically-based approach.

There is now an increasing interest in the use of so-called 'New Technologies' in this area. These are primarily of two types: (i) biochemical methods for the analysis of proteins and/or nucleic acids; and machine vision (image analysis) methods for assessing aspects of morphology.

Biochemical methods

The use of biochemical methods for taxonomic purposes (chemotaxonomy) offers the possibility of complementing the more traditional morphological approach. The power of such methods lies in their ability to reduce or even eliminate environmental interaction. The observed morphology, or phenotype of a plant is a result of the expression of its genetic make-up (genotype) influenced by the environment in which it is growing. By the analysis of genetic material (nucleic acids) or gene products (proteins), biochemical methods allow the genotype to be examined more directly.

Protein analysis

There is no doubt that of the biochemical techniques available for variety identification, the analysis of seed and seedling proteins and enzymes is by far the most widely used and successful to date. Because they are direct gene products, proteins can be used as 'markers' for the genes that encode them. For identification purposes, it is necessary to use proteins that are polymorphic (that is, exist in multiple molecular forms) and it is also

useful if the proteins are relatively abundant and easy to extract. For these reasons, much attention has been focussed on seed storage proteins. It is also important to have available methods for the analysis of protein composition. Two primary methods commonly used include:: the various types of gel electrophoresis; and high pressure liquid chromatography (HPLC).

Protein and enzyme electrophoresis is undoubtedly the most widely applied method of biochemical variety identification and its uses in this area have been comprehensively summarised and reviewed in recent years (Cooke 1988, 1989 Smith and Smith 1992, Wrigley 1992). There are many reports in the scientific literature of the application of different types of electrophoretic analysis to proteins and enzymes from a wide range of species of agricultural and horticultural importance. However, particular attention has been given to cereal species, especially wheat, barley and maize. Most methods for wheat and barley utilise polyacrylamide gels to analyse seed storage proteins (gliadins and hordeins respectively), whilst the most widespread method for maize employs starch gel electrophoresis to examine 12 seedling isozyme systems. Organisations such as the International Seed Testing Association (ISTA) have been active in the testing and approval of standard reference methods.

Electrophoresis methods can provide a high level of discrimination between varieties. For instance, at the NIAB, we have shown that it is possible to identify uniquely about 90% of a collection of over 200 wheat varieties on the basis of their gliadin composition alone. With barley, nearly 400 varieties can be classified into 70 groups as a result of the electrophoretic analysis of hordeins.

Electrophoresis has been successfully used for variety identification in more than 50 species (Cooke 1988, Smith and Smith 1992). The precise methods employed, both for protein analysis and for interpretation of the data, vary according to the species in question and are governed to a large extent by the reproductive behaviour and the consequent genetic structure of varieties. Overall, however, electrophoresis provides a rapid, relatively straight-forward and powerful method for testing varietal identity and purity.

Electrophoresis methods have found a number of practical applications within the seeds sector. In addition to plant breeding, these include: determination of varietal identity and/or purity; distinctness and uniformity testing; seed certification and hybrid purity assessment; seed testing (species identification); quality control of grain being used for processing; and documentation of genetic resources.

An alternative way of analysing proteins is to use reversed-phase HPLC. Since 1983, it has been demonstrated unequivocally that HPLC will successfully separate seed proteins of wheat, barely, oats, maize, rice and other crops. Moreover, since the data produced by HPLC are in a form which allows quantification of separated proteins, extra information is available which can be useful for identification purposes. HPLC data are also amenable to computerised storage and handling and the whole procedure (apart from protein extraction) can be automated to a large degree. The main disadvantages of HPLC lie in the relatively slow throughput of samples and the comparatively high cost and degree of sophistication of most HPLC equipment. Hence electrophoresis is probably more flexible and generally useful for variety identification, although HPLC has its place

and these techniques are perhaps best viewed as complementary to one another.

Nucleic acid analysis

An extremely powerful method for variety identification might be available if it were possible to detect variability between varieties in their genetic material (DNA). The technical problem is to find methods which can be utilized to reveal variations in DNA composition. In order to assist in this, it is necessary to cut the very large DNA molecules into smaller fragments. It is only comparatively recently that enzymes (restriction endonucleases) have become available which enable this to be carried out. Restriction enzymes recognize short specific DNA sequences, usually 4 to 8 nucleotides in length, and cut (restrict) the DNA within or adjacent to these sites. Variations in DNA sequences can be detected as changes in the number, or more usually, the length of the fragments resulting from restriction and are known as restriction fragment length polymorphisms (RFLPs). Hence, at the simplest level, RFLPs are variations in the size of restriction enzyme - generated fragments of DNA. The variation is detected by separating the fragments on an electrophoretic gel. A difficulty with this approach is that in reality, the gel patterns produced are very complex, since many thousands of DNA fragments are produced following restriction. Thus clearly separated bands are usually not produced and a way has to be found of highlighting fragments of interest. The solution is to use DNA probes. A probe is a small piece of DNA which is homologous to part or all of the fragment of interest and hence will hybridise with it. The major advantage of RFLPs lies in the vast number of combinations of restriction enzyme and probe. The technology offers an essentially unlimited supply of genetic markers and, given a suitable set of probes, a much larger portion of the genome can be sampled for RFLPs than for morphological or protein markers. Thus the power of RFLP analysis for identifiation purposes is greater than even the best electrophoretic or HPLC systems (Ainsworth and Sharp 1989). Various alternative approaches to RFLP analysis exist, the most promising of which for variety and seed work probably are those which do not require the use of radioactive probes, ie,

- DNA 'finger-printing' using repetitive oligonucleotide sequences (eg (GATA)n) as probes, labelled either with biotin or with digoxigenin (Weising et al. 1991);

- Techniques based on the polymerase chain reaction (PCR), such as the recently reported RAPDs (random amplified polymorphic DNA, Rafalski et al. 1991). This uses short oligonucleotides of arbitrarily chosen sequence to amplify, via PCR, fragments of genomic DNA, which can then be separated by electrophoresis and directly stained. These are early days for a proper assessment of DNA analysis for variety identification work, but the available potential is clear and work is underway to evaluate systematically the various different possible approaches and applications.

Machine vision

As was mentioned earrlier, morphology-based taxonomy requires replicated and lengthy measurements and statistical tests in order for distinctness or identity to be established. An alternative to

this would be to make use of machine vision systems. Simply, machine vision refers to the acquisition of shape and size data using a video camera or similar system and the subsequent analysis of these data following suitable processing. The term image analysis is often used in this context, but strictly refers to the extraction of numerical data from an image. In addition to providing an automated means of making measurements, the great attraction of machine vision is that it is possible, via the appropriate software, to make detailed comparisons of sets of data, ie, to operate pattern recognition systems. This makes such systems potentially very attractive for variety description and identification.

Work at NIAB has concentrated initially on the use of machine vision for the identification of wheat varieties from seed measurements. First experiments, based on the use of 10 shape descriptors of a silhouette image of seeds, showed clear differentiation between a limited number of varieties. This work has now been extended and the number of useful shape descriptors (measured and derived) increased to 69, which enables virtually all of the shape information present in the outline silhouette image of a wheat seed to be recovered (Draper and Keefe 1989). Work is in progress to improve the statistical methods used to distinguish between varieties, with the aim of being able to determine not only varietal identity but also purity.

Preliminary experiments with barely using the same approach produced promising results and it was possible, for example, to discriminate between some pairs of varieties which are identical following analysis of hordeins.

The use of machine vision technology offers considerable potential for variety identification. The main advantages lie in the speed and ease of operation of the equipment. However, this does rely on research having been carried out to establish: (i) appropriate character sets for identification; (ii) suitable statistical methods of analysis; and (iii) a database of information relating to existing varieties.

It may be that ultimately the best use of such technology is for variety description purposes, rather than variety identification *per se*.

Conclusions

There is no doubt that the use of biochemical techniques and computer-aided machine vision systems can provide a rapid, reliable and highly discriminating means for the identification of varieties. Some of these methods have already found widespread use and acceptance with certain sectors of the seeds industry. Other possible 'New Technologies' also exist and are under investigation, such as immunological methods for the detection of particular proteins of other components, and recently developing electrophoresis techniques such as capillary zone electrophoresis (CZE). The widespread use of more modern techniques in plant breeding and the imminent availability of transgenic (genetically modified) organisms, along with the need for overall improved seed quality control, will surely mean that more use is made of all of these methods in the future.

REFERENCES

Ainsworth CC, Sharp PJ (1989) The potential role of DNA probes in plant variety identification. Plant Var Seeds 2 : 27-34

Cooke RJ (1988) Electrophoresis in plant testing and breeding. Advan Electrophor 2 : 171-261

Cooke RJ (1989) The use of electrophoresis for the distinctness testing of varieties of autogamous species. Plant Var Seeds 2 : 3-13

Draper SR, Keefe PD (1989) Machine vision for the characterization and identification of cultivars. Plant Varieties and Seeds 2 : 53-62

Rafalski JA, Tingey SV, Williams JGK (1991) RAPD makers - a new technology for genetic mapping and plant breeding. AgBiotech News Inf 3 : 645-648

Smith JSC, Smith OS (1992) Fingerprinting crop varieties. Advan Agron 47 (in press)

Weising K, Beyermann B, Ramser J, Kahl G (1991) Plant DNA fingerprinting with radioactive and digoxigenated oligonucleotide probes complementary to simple repetitive DNA sequences. Electrophoresis 12 : 159-169

Wrigley CW (1992) Identification of cereal varieties by gel electrophoresis of the grain proteins. In: Modern Methods of Plant Analysis (New Ser) 14, Seed Analysis (in press)

Constraints in Crop Improvement

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While the significant role of the All India Coordinated Crop Improvement Projects in ushering in the 'Green Revolution' is readily recognised, the institutional innovation that has been pivotal to this change does not appear to have been appreciated. Multidisciplinary approach to production problems, cooperative planning, programming and conduct of crop improvement research, free exchange of material, flexibility in operation cutting across administrative and other boundaries, were the cardinal elements in this institutional innovation. A national research grid was forged out of a what were scattered, independent, duplicating efforts some of which competed with each other for resources and material. The innovative nature of the institutional change was highlighted by Rao (1989), and also by Paroda (1990) who made a deep and critical analysis of the system. This needs to be reiterated here since there does not appear to be any comparable instance of an institutional innovation resulting in such a high pay off in production. The establishment of an institute for research on the rubber crop in Malaysia which has led to a six-fold increase in rubber production in that country appears to be a close parallel. The fact that we have assembled here for an on-course correction process, is itself a measure of the flexibility of the system.

Plateauing or declining trends in crop productivities as the green revolution appears to be losing its momentum, higher costs of productivity gains (fertilizer use efficiency down from 17.1 kg of grain per kg of fertiliser in 1970-71 to 8.1 kg in 1988-89), wide gaps in the productivity levels of the farmers' fields and demonstrations (narrowest is 30% for wheat in the Punjab), are the signs that forewarn changes to be not only desirable but imperative. The first coordinated crop improvement project was initiated in 1957 on maize. In the past three decades since then the agricultural scene in the country has witnessed profound changes. More land has been brought under the plough, new crops (soybean, sunflower) have been introduced, and in some areas traditional crops are being given up (bajra and groundnut in the Punjab). Consumer demand profiles are changing. The country had in 1989-90 exportable surplus of one million tonne of wheat, 0.7 million tonne of rice and 60,000 tonnes of castor oil. it is natural to expect the coordinated crop improvement projects to respond to these changes appropriately. The basic philosophy on which the projects were founded, the fundamental principles guiding their operations are still relevant to the current situation. Our task is now to decide on the direction and magnitude of ameliorative changes in the system that need to be initiated.

In this presentation an attempt is made to identify those areas in the crop improvement programmes that may require our immediate attention in our

exercise to bring about changes. The coordinated research project system now snapsa wide spectrum of crops with diverse production characteristics in space and time, mating systems and the nature of the economic produce. It is not possible to critically examine each of these projects to identify the aspects that require major changes. Nor is that necessary to do so since apart from requirements dictated by the specific crop commodity being handled, the projects show similarity in their structure and function. Hence, it is hoped that comments arising out of an overview of some of the projects (on wheat, rice, maize, bajra, groundnut, cotton and pulses) are of general applicability to the entire system.

First an analysis of the constraints encountered in the functioning of the projects is made. For the sake of better understanding these are considered as conceptual, methodological, and procedural. A few suggestions as to the dealing of these constraints are made.

Conceptual issues

Of all the conceptual issues concerning the coordinated projects none is more important than the absence of well articulated goals of production and productivity. In none of the projects has this been well defined, nor a time frame fixed for its achievement. Some project documents do mention *en passant*, production goals to be achieved. These are generally figures borrowed from planning or administrative sources (generally unrealistically high 25% annual growth rate for bajra, 10% for pulses). But even these figures do not seem to have been taken into account while formulating crop improvement research programmes. In this connection it is well to recognise the distinction between targets and goals. Goals are planned levels of attainment towards objectives at specific times contributed by specific policies and programmes. Targets, on the other hand, are related not to objectives but to means. A further refinement of this is the fixing of goals in productivity to be achieved for the different regions of the same crop differently depending on the production potential of that region. Although several crop coordinated projects operate on a zonalised basis, production or productivity goals are not so conceived. The urgent need to fix specific goals in production and productivity cannot be over emphasised. The Food and Agriculture Organisation of the United Nations has fixed, in dealing with food security, a global annual growth rate in production of 2.6% for wheat and 2.3% for rice as being critical. In the Indian context increases in food grain production has necessarily to be achieved through productivity gains as room for area expansion is extremely limited. Thus, the responsibility of the breeder for this is apparent. It is also essential that the time frame for the realisation of the goals be also fixed. In practice, this will take the form of fixing the dates of termination of individual experiments. Except in the case of pulses, none of the projects has indicated the dates of conclusion of research programmes, which all appear like open-ended ones.

Estimates have been made of the rates of growth of productivity in our major crops on a nation-wide scale. But for our current purposes, an assessment of the productivity gains in the varietal improvement programmes of the experimental stations will be more instructive in indicating levels of attainment in this regard. Some estimates are given in Table 1 for a few of the crops. It is seen that gains in productivity, during the ten year

Table 1. Productivity gains in experimental stations from selected genotypes during a 10 year period, 1981-1990

Crop	1981	1991	Per cent Increase (of 1991- over 1981)	Per cent National Productivity Gain (Compound rate 1967-68 to 1988-89
Wheat				
Genotype	WA 283	WH 542		3.17
Productivity (kg/ha)	4240	4910	15.8	
Increase *	4.5%	6.3%		
Rice				
Genotype	IET 5897	IET 11064		2.06
Productivity (kg/ha)	4715	4769	1.1	
Increase	8.6%	10.1%		
Maize				
Genotype	MSI DR 30-1-3 x MSL DR a 120-2-1	SSM 5010		1.00
Productivity (kg/ha)	4968	5992	20.6	
Increase	15%	14.8%		
Bajra **				
Genotype	GHB 27	GHB 181		0.81
Productivity (kg/ha)	2287	3211	41.1	
Increase	3.9%	14.8%		
Chickpea				
Genotype	GC 588	ICCV 88102		0 22
Productivity (kg/ha)	2207	2366	5.8	
Increase	15%	24%		

* = Increase over best check; ** = Data for Gujarat

period 1981 to 1991, are marginal except in maize and bajra. The improved genotypes themselves are only marginally superior to their corresponding checks. This indicates the stagnancy or plateauing of productivity gains despite this period witnessing an aggressive programme in the improvement of the crops. The situation does not appear to be unique for the Indian efforts. The International Rice Yield Nurseries (Medium) from the IRRI contained some high yielding genotypes (over 5 t/ha and 18.6% over the check) when tested at 15 centres of the Rice Project in 1981. But in 1990 none were so outstanding either in this trial or in the International Nursery for the Genetic Enhancement in Rice set. It may be pointed out that the rice genotype IR 8 evolved in 1966, established an yield potential of 10 t/ha, under stress free environment, is still unsurpassed.

From these considerations it appears pertinent to ask whether grain yield is a 'character' at all, or just a mental construct? Whereas resistance breeding programmes have resulted in demonstrable seed yield increases, production breeding programmes, other than those exploiting heterosis, have little achievement to their credit. This is inspite of the many studies on the 'genetic architecture' of seed yield,

estimation of gene action of traits developmentally associated with seed yield, or the various selection indicies formulated. These biometrical parameters estimated have been used more to rationalise breeding results obtained already, than to formulate specific breeding procedures aimed at more efficient manipulation of seed yield.

Basic to the above situation is the fact that the production physiology of the grain crops have been studied little, and understood much less. Recognising the need for basic physiological information on the major grain crops, the coordinated projects have been provided with one or more research centres of physiology each. It cannot be said that the activities of these research centres on physiology have aided the breeder in a substantial way. Although the physiology of function, particularly in biochemical terms, can be considered outside the mandate of the physiology centres, that of form can yield valuable information to the breeder, if interpreted in physiological terms. In the field of applied physiolog treatments with antitranspirants, hormones, drought hardening chemicals, are treated like agronomic variables, and no physiological slant is given in the interpretation of the results. Genotypes remain uncharacterised for their photo/thermo sensitivities. The root system of the crops have not been studied in detail to screen genotypes for their reaction to drought, or fertilizer use efficiency.

With such a poor physiological backup, it is not surprising that the projects have been rather slow in formulating specific ideas on the concept of plant type as a target of their breeding efforts. The question that should be asked is whether the plant type concept is still useful or has become outdated. Twenty years ago this author made out a case for the breeders to recognise the dichotomy, 'input-intensive' and 'stress intensive' systems of crop production and develop appropriate plant type models for each (Parthasarathy and Rajan 1972). This appears to be of greater relevance today, as productivities tend to plateau in monocultural, input-intensive production systems, and in the absence of breakthrough in yield ceilings future gains in output must increasingly come from rainfed conditions. Consequently, this calls for a whole gamut of changes in concepts, attitudes, programmes and procedures on the part of the breeders. Productions are likely to be based more on mixed, multiple or relay cropping systems. Heterogenous-homozygous/heterozygous populations would be the breeding end products. Breeding researches will have to be conducted, if not in its entirety, at least in the final stages under real farm conditions. We should anticipate higher levels of treatment-by-environment inteaction effects, and adequately design our experiments on the farm to quantify them. Phenomena like genetic homeostasis, populational buffering, inter-genotype competition, or gene conditioning (in the sense of Durrant 1962), will become relevant in the buildingup of productivity populations. The breeder should be prepared to face the question, how much yield of his crop he is prepared to sacrifice, to facilitate the planting of a succeeding crop or the harvesting of the preceding one. Accustomed to 'Maximum Yield Research' (MYR) programmes, he will have orientate his work towards (MEY) 'Most Efficient Yield' (MEY) programmes. While it might be technically correct to aver that every production problem has a genetical solution, it might not be the easiest, quickest or cheapest way of solving it. The need appears to be a systems approach (not to be confused with farming systems) to

production problems. To sum up, the crop breeder should consider himself and his work as only a component, an important one, of an area based improvement programme.

It is easy to see that the preceding paragraph contains elements of what is now popularly called, 'sustainable agricultural system'. Also variously referred to as 'alternative agriculture', 'organic farming', 'regenerative farming', or 'Low-Input-Sustainable-Agriculture (LISA). For a detailed definition of concepts involved (see Keeny 1990). It is adequate if the crop breeder poses the question 'is it possible to further intensify productivity of the crop and still do it in a environmentally safe way?. 'Sustainable agriculture is not a return to the subsistence farming of the 30s. High productivity levels are possible, as for instance, 5 to 6 tonnes per hectare of rice with only the incorporation of *Sesbania* and without using any chemical fertilizers. Sir Albert Howard's 'Indore Method of Composting', or the campaign of the Tamil Nadu Department of Agriculture, for planting *Sesbania* or *Glyricidia* on field bunds during the 50s, can be considered as trail blazers in this regard.

Methodologies

Pedigree breeding and the exploitation of heterosis in single or double cross combinations have been the main methods adopted by most of the crop improvement programmes. The backcross method has also been successfully employed mostly in resistance breeding programmes (too well known and numerous to mention), as also in quality improvement programme in cotton (Singh 1990). These are no means achievements. But, one does discern a hesitation on the part of the breeders to depart from the beaten track and try innovative technique and approaches. This might be due to the initial success of the earlier programmes. But, viewed from the fact that the 'Green Revolution' has indeed a very narrow base (one crop-wheat; one genetic trait-dwarfism; one area the Punjab-Haryana-Uttar Pradesh belt;) its high degree of vulnerability is apparent. New strategies have to be forged and in addition to conventional methods, others not so conventional have also to be employed.

Germplasm collection in crop plants is the foundation on which breeding effort rests. Those crop projects that have established working relationship with International Crop Research Institutes are well served in this regard. The collections are augmented on a continuing basis (over 3400 accessions were added in 1989-90 to wheat germplasm, and nearly 6000 to the rice germplasm collection in 1988-89). In these two projects the germplasm is maintained, evaluated and useful material inducted into the breeding programme. In some others a large collection is not planted at all, being given a low priority in operations. The main problem appears to be the maximization of the chance of locating the desired trait in a cost effective way. Passport data of the collection, if available, could be of great help, since in the collection some traits get evenly distributed others occur in clusters. The breeder has to decide whether the search has to be random, sequential or stratified. In the case of cross pollinated crops like rapeseed, safflower or sunflower the validity of the accession numbers become suspect after a few seasons of open seed increase. In such cases it is worth finding whether carrying over the germplasm collection in the form of gene pools, one for each desired trait, is not the best method of maintenance. Fewer, and hence more easily manageable isolations will then be required.

While the enthusiasm of the breeders with which the exotic germplasm is sought, received, maintained and utilized is understandable, the reluctance to undertake indigenous collections of land races, and allied species of grain crops is inexplicable. Other than rice, no project has a systematic programme of collecting indigenous land races. The dangers inherent in such a neglect cannot be overemphasised. For instance, in Gujarat with almost 100% of the bajra area planted with hybrids, local cultivars have totally disappeared, and not fully represented even in the collections of the breeders. We are heading for a similar situation in Rajasthan for this crop. It is my surmise that seeds of wheat varieties released early in the century like, I.P. 4, or I.P. 52 are not likely to be available anywhere, in the country.

Only a few of the crop projects have initiated specific programmes to generatge genetic variation in the crops concerned. In the wheat crop this takes the form of backcross bulks, inter-specific derivatives, winter x spring wheat derivatives, and local types with dwarfing genes. In maize broad based pools are maintained into which new material of appropriate maturity and kernal colour are regularly introgressed. National crossing programme has been planned for both rabi and kharif pulses, but with poor implementation. One such programme initiated by the author in groundnut crop (which is notoriously invariable, since the entire commercial crop of groundnut can be traced back to few plants introduced into the country 250 years back) seems to have been discontinued.

The pedigree method in self pollinated crops and the exploitation of heterosis in the cross pollinated ones are the standard breeding methods employed. Minor refinements and modifications of these methods are available and can be profitably used. For instance, limitations of the pedigree methods can be overcome by the use recurrent selection; hybrids between parents, one of them not an inbred, retain their high productivity for several generations. There are several other methods, like the single-seed-descent method that improve the efficiency of selection procedures.

It is rather curious that our poor understanding of the genetical control of heterosis has not come in the way of the commercial exploitation of this phenomenon. Impressive gains that have thus resulted, as well as the seed industry it has spawned, has dulled the initiative in employing other breeding methods. Intensive search is launched for the isolation of the male sterile systems in self pollinated crops like rice, wheat, raya, pigeonpea and others. Whether this is an indication that all the available methods for the self pollinated crops have been exhausted, is an open question. It needs to be pointed out that of the three crops in which production percentage growth rates, during the period 1967-84, was in excess of the population growth rate *viz*, wheat (3.0), jowar (2.8) and ragi (2.27) (Rao 1991) only one achieved this through a hybrid programme.

If one were to ask a heterosis breeder that his requirements of an ideal system are, he might indicate the following:

- a high value economic crop
- exploitable heterosis
- a pollination system that results in 100% cross pollination effortlessly
- a dimorphic or monomorphic sexuasystem that require no maintainers or restorers

- high level of hybrid seed production per unit area, preferably both parents yielding hybrid seeds
- an easy selfing system to maintain the inbreds
- a high level of multiplication ratio
- plant capable of vegetative multiplication as well

Before one summarily rejects the above as an unrealistic ideal, it only needs to be pointed out, this exactly describes the self-incompatability system in oil *Brassicas* (brown sarson, toria). Notwithstanding this the crops remain untouched by heterosis breeding.

Ideotype breeding in which the genetic yield potential is sought to be enhanced through the modification of individual traits the breeding goal for each of which is specified, can be profitably employed particularly in situations where breeding for seed yield *per se* has tended to plateau. Rasmusson (1987) has suggested that 75% of the programme could be devoted to yield breeding and 25% to ideotypoe breeding. Similar apportioning of the breeding work between the two types of activities may be undertaken. But as pointed out earlier the lack of information on the physiological basis of the trait and its relation to seed yield are the difficulties involved. Companion cropping production systems and the use of varietal blends (mechanical), can benefit from ideotype breeding, if genotypes could be screened and selected for the root system competing for water and nutrients and the canopy coverage competing for light.

The programme of populational improvement has not been paid the attention it deserves in crop improvement programmes. Even in crops where hybrid seed production is relatively easy due to floral morphology, or sexual sterility, genic or cytoplasmic, population improvement programme can be used to overcome plateaus in production, by alternating it with the hybrid programme. In crops which are cross poallinated but with hybrid seed production relatively difficult, making use of natural panmixix, and isolation, spatial or temporal, genotypes selected on the basis of general combining abilities could result in populations of higher performance. As emphasis shifts to sustainable production systems, the role of populations with their built-in environmental resilience due to heterogeneity of genotypes, will become increasingly significant. An innovative combination of mass selection (identity of the ancestry of genotypes not being maintained), and pedigree selection (genotypes selected on the basis of performance of half-sib progenies) has been shown to be quite effective (Rajan 1955).

This section on methodology can be appropriately concluded with a reference to genetic engineering/biotechnology, which is currently very much in the news. Conventional genetic improvement of crops in this country has been in the past touched by various new techniques, like induced polyploidy (or haploidy), induced mutations, quantitative genetics etc. These techniques did not have the expected impact not because of their inherent ineffectiveness but because of the over-ambitious expectations on the part of the researcher who expected to be relieved of the tedium of conventional breeding work. It is hoped that biotechnology will not be treated in a similar way. One of the potential achievements in this field projected by the experts is the induction of the ability to fix

atmospheric nitrogen by grasses. Such an achievement can be in the foreseeable future only if the host-pathogen specificity is under simple genic control, unlike the nitrogen fixing ability which is under multigenic control. It has been suggested that the host-pathogen specificity genes are predominantly in the host genome (Johnston et al. 1984). Hence success in this direction is a distinct possibility, but cannot said to be round the corner. That small improvements like disease resistance can be achieved in relatively shorter periods has already been demonstrated by the isolation of somaclonal variants resistant to the downy mildew disease in bajra.

Procedures

In this section a reference will be made to certain procedural issues in the operation of the crop improvement projects that may require our attention while effecting changes.

One would have very much liked to see in the annual reports a priority listing of activities according to the approved technical programme, in the descending order, so that in the event of restricted resources, anticipated or otherwise, deletion of the items of activity can be undertaken.

There appears to be an excessive preoccupation with the conducting of trials, of various hierarchal categories, of finished material. Much less time and effort are spent on the gener ation of breeding material. While such disparities could be justified in the earlier stages of the project, when it had no more than a few introductions and land races to evaluate, in projects more than two decades old, there must have been an accrual of breeding material generated in the past and being continued. An account of these should find place in the reports. This is not to diminish the importance of conducting trials of finished material. They do fulfill an important purpose, but they represent the concluding phases of a breeding programme.

On the other hand the voluminous data collected each year do not seem to have been subjected detailed analyses. Enormous amount of useful information lies submerged in these data collections and could be extracted with great benefit. Since most of the centres of the projects have access to EDP facilities it should not be very difficult to include in the tables correlation analyses of traits scored with seed yield. Multilocation trials if not subjected to genotype-by-environment interaction analyses could be considered as wasted. Like wise there is a substantial accumulation of data over the years on cropping systems with the crop of the project as the major component. If subjected to meaningful analyses along with weather data it could release meaningful analyses along with weather data it could release a fund of rewarding information.

A matter of great concern is the distance between the breeder and other scientists in the projects. The distance referred to is not the physical distance but mental distance. There was an instance of a breeder in a project running his own disease-sick plots to screen genotypes, while the pathologist of the project was also doing likewise as a part of his technical programme. There was also another instance of an entomologist in a project was unaware of the resulte from the headquarters of another ICAR coordinated project for the same pest, located just a few metres away. Agronomists apply their experimental variables in the field on varieties recommended by the breeder for

replacement by later releases. It is sincerely hoped that these are only isolated instances, and don't represent a general pattern.

Of far greater concern is the lack of contact between the breeder on the one hand and extension service personnel on the other. The breeders' contact with the primary producers of the crop, the farmer, is also very ephemeral. In such a situation one wonders how problems are brought to the notice of the breeder for solution? When the problem becomes self evident by its sheer magnitude, as for instance and epidemic of a disease, it is too late for intervention by the breeder. In a questionnaire survey conducted by the author less than 10% of the breeders who responded identified personal visits to the farmers' fields as a primary source of problem identification. In this context, therefore, the recent emphasis on 'front line demonstrations' has been very appropriate and timely. It should be pointed out that demonstrations however well conducted, do serve research but poorly, while on-farm breeding experiments as suggested in 2.5 of this paper, can be appropriately designed to serve also as demonstrations.

The significant role of the extension programme and its indispensability to the breeder was most dramatically demonstrated by the Technology Mission on oilseeds launched in 1986. The Mission did not introduce any new technology, but spread the available technology across, identifying the extension efforts (or the lack of them) as the weakest link. A combination of the Mission's efforts good monsoon and favourable market prices was able to lift the national production of oilseeds from 10.8 million tonnes in 1985-86 to 19.2 million tonnes in 1990-91.

The general practice in the breeding projects is to finalise the evolution of the variety and then pass it on to the agronomist to identify the production optima for it. Only in some special cases like late sown conditions, or saline soils the agronomic variable is employed in the evolution of the variety. Whether this should not be the general pattern so that the variety and its production optima are simultaneously evolved, is for consideration. Or to take this concept even further whether agronomic variables should not also function as selection screens. The importance of this will become more apparent as emphasis in production strategy shifts from commodity-oriented to area-oriented programmes.

As the projects progress in time it is natural to expect changes in priorities, policies and procedures, and new activities to be undertaken with changed emphasis and orientation. But past events and observations continue to be relevant to the new programmes, and this requires an efficient retrieval system. The simplest way to effect this is to have a project file for each study, complete with all relevant information and summerised data. An estimate of the costs involved each year till the closure of the study should be a welcome addition. This will enable an economic assessment of the study be made.

While dealing with the economic assessment of results from the activities of the projects, it is for consideration whether an estimation of the cost of information gathered from field trials be made both interms of financial costs and time costs. This would relate directly to the success of field trials. The performance of the different Projects in this regard is highly variable. The number of field trials that were rejected as unacceptable ranged from 21% in maize (1990) to 68% in kharif pulses (1990-91).

The basis of rejection was the high levels of coefficients of variation of the mean values above 20%. Poor control of the non-expeprimental variables and poor field management are responsible for high levels of rejection and should be avoided.

It is the practice that projects hold annual workshop meetings to review the data collected and plan for the following season. In some projects sub-workshops based on region or season are also held. It is appropriate to enquire whether these meetings do serve the purpose they were originally intended to. While reviewing the work of the project on bajra it was suggested (Rajan et al. 1991) that such workshops be held once in three years to enable positive and a affirmative conclusions be drawn from pooled data analyses, and in the other two years single theme discussions or single region discussion be undertaken. The meeting will be held annually as hitherto, but the focus in two of the meetings will be different.

It is also suggested that all the crop improvement projects should undertake as early as possible a one-time meet to discuss in depth the strategies to be adopted in the next decade.

Conclusions

While considering the nature and extent of changes that need to be introduced into the system of All India Coordinated Crop Improvement Projects three options are available as follows:

i. there is no need for the projects to continue vis a vis the establishment of State Agricultural Universities, and hence could all be terminated

ii. the projects in their present form meet all the requirements of the changing situation and should be allowed to continue in the present format with only minor changes

iii. the main framework of the project system is its greatest strength, and should be retained. But the changing agricultural situation requires fundamental changes in the policies, programmes and procedures. These should be initiated without delay.

Assuming the third option to be the one of choice, the changes that need to be introduced in the crop improvement programmes have been outlined in the previous sections.

An institutional innovation like the coordinated crop improvement project, that responded so admirably to catalyse a change that ushered the 'Green Revolution', can certainly respond again to a change to a greater emphasis on sustainability of production systems. At the one extreme it has to integrate with basic disciplines like physiology, and at the other extreme applied activities like extension and on-farm experimentation. This will demand, more than anything, changes in the attitude of workers in the projects. There is no doubt that the institutional system as well as the workers in it have the resilience to respond in a prompt and beneficial manner.

Summary

The establishment of the All India Coordinated Projects should be considered as an institutional innovation, and should be treated as such while considering initiation of changes necessitated by the changed agricultural situation in the country.

For the purpose of this discussion the changes that need to be introduced are

considered under three heads, i.e., conceptual, methodological and procedural.

Conceptually, the projects should (i) fix appropriate goals and targets for grain productivity gains, in the short term and long term perspectives, (ii) undertake or cause to be undertaken basic physiological studies relating to yield, and integrate the results with breeding efforts towards a more efficient genetic manipulation of yield, (iii) reorientate commodity-based policies and programmes in such a way as to render crop improvement as a component of area-based improvement programmes.

Plateauing of productivity gains is observed not only in the national production but also in the experimental station yields indicating poor efficiency of improvement methods employed. While conventional breeding methods should be continued to be employed modifications of these and new techniques are to be introduced.

A case is made out for greater contact of the breeder with extension workers as well as with farmers. A greater amount of on-farm experimentation has to be undertaken than hitherto.

A plea is entered for procedural changes, which may include, priority listing of activities, greater attention to the generation of breeding material, in-depth analyses of the data collected, using agronomic variables as selection screens and greater interdisciplinary collaboration. Workshop meetings could be less frequent and more meaningful. Maintenance of project files, and costing of experiments both in terms of money and of time, are suggested.

The breeder should modify his policies, programmes and procedures to suit to the demands of sustainable production systems that are expected to dominate the agricultural production scene of the future.

REFERENCES

Durrant A (1962) The environmental induction of heritable changes in *Linum*. Heridity 17 : 27-61

Johnston AWB, Gotz R, Hombrecher G, Ma QS, Knight CD, Rossen Mudd Ea, Ribb NJ, Downie JA (1984) Molecular biology of nodulation, host-range and nitrogen fixation genes of *Rhizobium leguminosarum*. Proc 15th Int Cong Genet, New Delhi, 2 : 195-204

Kenny D (1990) Sustainable agriculture: definitions and concepts J Prod Agric 3 : 281-285

Paroda RS (1990) Nationally coordinated research programmes : organisational framework and managerial aspects of the All India Coordinated Crop Improvement Projects. Paper presented at DR & SS/ISNAR/SACCAR workshp on the Management of Change. Zimbabwe : 19-23 February, 1990. pp14

Parthasarathy N, Rajan SS (1972) Plant breeding strategies for the seventies with special reference to the developing countries in the tropics. Int Rice Com Newsl, 21(4) : 1-17

Rajan SS (1955) The effectiveness of the mass pedigree system of selection on the improvement of seed setting colchicine-induced autoteraploids of toria. India J Genet 15 : 47-49

Rao GVK (1988) Report of the ICAR Review Committee. ICAR, New Delhi, pp 170

Rao NGP (1991) Coarse cereals: role in poverty alleviation. In : Survey of Indian Agriculture, 1991. The Hindu, Madras, India, pp 66-71

Rasmusson DC (1987) An evaluation of ideotype breeding. Crop Sci, 27 : 1140-1146

Singh TH, Chahal GS (1990) Transfer of fibre length through backcross method in upland cotton. 35th Annu Meet of the Crop Sci Soc Am, Agron Abs, pp 100

Concept and Coordination of National/Regional Research Networks

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Coordinated approach to crop improvement, a unique experiment that enabled the country to witness a spectacular advance in agricultural production and productivity during the last three decades is a significant landmark in the history of Indian agricultural research. Multi-discipline based multilocation testing, a novel mechanism among the various built in features of the All India Coordinated Crop Improvement Projects (AICCIPs), has been instrumental in accelerating the process of targeted production advance by rapidly and efficiently catering to the fast changing technology needs of varied agro-ecologies. The AICCIP's are massive in size and magnitude and cover a wide spectrum of crop plants involving sizable scientific manpower. Professionally dynamic in functioning, AICCIPs are becoming increasingly a routine affair. The mandate originally spelled out for each projects, has enough room to make every programme continuously productive. Yet, very little has been done to diversify to cope up with the changing agricultural scenario. In the four-tier technology generation - dissemination process, the role of coordinated projects has hitherto been largely confined to 'technology evaluation', which was then the immediate need. With fast changing needs and urgency, there is a wide scope to make use of the well organised system and the vast under-utilised talents available under AICCIPs for the 'knowledge generation' and need-based 'technology evolution'. An attempt has been made here to review the relevance and potential of 'network approach' to knowledge and material generation, and suggest the scope for extending the concept to various research areas of promise.

Research component in AICCIPS

Conducting both lead and strategic research on problems of regional and national priority' has been envisaged as one of the mandate of AICCIP's besides the major role of 'rapid identification of appropriate varietal and crop management technologies'. Yet, the objective remains unfulfilled in most of the projects. The lead research is often confined to the coordinating centres (headquarters). When several problems remain either unattended largely due to paucity of basic research information, hardly 30% of the time of the cooperators are made use for the project work under the coordinated projects. Routine responsibility of conducting coordinated trials/screening, stress nurseries has left no scope for the highly qualified and competent centre scientists to develop their intellect and skill.

Coordinated research networks

Concept and criteria

Conceptually, a 'research network' is a 'collective research endeavour' to achieve a common goal of interest at regional or

national level. The network may aim at either generation of basic information that is necessary to plan/aid a potential applied research or development of a viable technology - commodity or system oriented. This approach requires an exclusive and concerted research effort.

Organizationally the network, depending on the nature of the problem, may be constituted of centres that experience a constraint, centres with similar/common opportunities, centres with scientists having capability and a minimum research infrastructure. A model coordinated research network would comprise, 2 to 3 lead centres, 6 to 8 associate centres for carrying out applied aspect of the research programme; 2 to 3 strategic research centres for generating basic information; and the coordinating unit at headquarters (Fig.1). Besides, linkages can be established with other national projects/ institutions or with international institutions, depending on the need.

The following are some of the criteria for identifying thrust areas for network approach.

- Problems of national or regional priority requiring either single or multidisciplinary research strategy.
- Potential areas but of slow or no progress for want of collective and concerted effort.
- Areas that could be managed with least additional scientific manpower and limited research infrastructure.
- Basic research, findings of which would help accelerate applied research of economic significance.

Relevance and urgency

The success of all ongoing agricultural research and development efforts in the country would be determined hereafter by the level of selfsufficiency and sustainable surplus in respect of agricultural commodities in general, and food in particular. Slow growth rate of production as against increasing growth in demand, increasingly complex and unmanageable pest-disease epidiemics and silent erosion of soil health seriously threatening the stability of our existing production systems. There is un urgent need to prevent the rapid depletion of genetic variability in the primary and secondary gene pools, on which AICCIPs depend. Taking full advantage of the existing coordinated testing system and manpower strength, there is scope to formulate strong and viable problem specific research networks with the broad objectives of ensuring: The targeted annual productivity of growth; Stability in production and productivity; Reasonable profit margin for motivating the grower; and Environmental safety.

Possible area in selected crops

There are many and varied areas (Table 1) requiring network approach to find rapid and effective solutions. Concerned crop scientists can collectively identify and prioritize the researchable areas to achieve such objectives. In some of the identified areas, such networks are already in progress as discussed below.

Exploitation of hybrid vigour

For stepping up food/oilseed production in the next decade, following areas have been identified for development and use of hybrid technology; in maize and sorghum for rabi; bajra and cotton for

Table 1. Areas for network research in selected crops

Productivity advance
Hybrid technology in selected crops (Rice, Wheat, Arhar)
Exploratory cultivation in areas/seasons (Rabi Maize, Boro Rice)
Research methodology for development of composite varieties (Maize)
HYVs of export quality (Basmati rice, Durum wheat)
Cropping systems (wheat-rice)
Stable performance
Epidemiology of disease (Karnal Bunt, Sheath blight)
Biological control of diseases/insect pests
Disease forecasting
Durable resistance
Resurgence and resistance to pesticides
Use of alien genes for pest resistance
Declining trend of response to N,P,K
Germplasm
Germplasm evaluation and documentation (wheat, rice)

earliness; and sunflower for disease resistance; and rice, Brassica and red gram for raising the yield ceiling. The project, wholly funded by ICAR, has been fashioned in the pattern of research networks involving representative centres in the targeted areas for each of the crops. During the short span of two years, the coordinated effort has led to evolution of a large volume of promising material besides identification of one or two heterotic hybrids for immediate exploitation in the traditional crops.

In the case of rice, where the yield levels of the currently cultivated HYVs are tappering off, especially in high productivity irrigated areas, the effort is to reaise the 'genetic yield ceiling'. Among the available technology options to break the yield barrier, hybrid technology has been found highly rewarding in China. Having failed to exploit the technology with the Chinese material during the first 15 years, a fresh attempt is now being made through a research network to develop a commercially viable hybrid technology. The network, initially funded by ICAR and now jointly with UNDP, consists of one lead centre each in the north (Kapurthala) and south (Mandya), two associate centres in the south (Maruteru and Coimbatore), three in the north (Karnal, Pantnagar and Faizabad) and one each in the eastern (Chinsurah) and western India (Karjat) and three strategic research centres (CRRI, IARI and DRR) with DRR coordinating the entire dprogramme. For optimization of seed production, respective public sector seed agencies located in the target areas are also actively involved (Fig.2). The accomplishments made under the project in a matter of two years are quite impressive.

Over 100 hybrids have been identified yielding a tonne than the best traditional varieties. Seed yields have been increased closer to 2 t/ha. Hybrid rice project is one of the best examples to demonstrate what could be achieved through network research effort. There is considerable scope

to extend this approach to wheat, sesamum etc.

High yielding varieties of export value

The decline in the foreign exchange reserves and slow growth rate since many years necessitated the development of rational policies for stepping up the quantum of our exports. Basmati rice is one of our major export commodities and the demand for this superfine scented rice is on the increase in the international markets. It accounts for 64% of the foreign exchange earned from agricultural commodities excluding plantation crops and marine products. During the last decade, basmati rice export increased by more than six times, to reach 39.6 mt. Even non-basmati rice is exported. According to available rough estimates, India earned nearly Rs.600 and 250 crores respectively through basmati and nonbasmati rices export during 1990-91. With a closing stock of rice exceeding 11 mt during the last few years, there is a scope for India to export annually 2 mt of basmati and nonbasmati rices. Attainment and sustainability of this goal would depend on our improving the poor yielding traditional basmati rice varieties for higher yield and resistance to major pests and diseases. Limited success has only been achieved, though there has been persistent research effort since mid-sixties, to combine high productivity of the semidwarfs with the key quality features of basmati rice. ICAR has initiated a couple of years back, a network research programme with the objective of evolving high yielding basmati rices for export purposes. The network comprising three strategic centres (IARI, New Delhi; DRR, Hyderabad and CRRI, Cuttack) and four (HAU, Kaul; GBPUAT, Pantnagar and PAU, Kapurthala and Ludhiana) as applied research centres with DRR shouldering the responsibility of coordination, has made impressive progress (Fig. 3) during the last three years. Starting with the most popular and the world's first high yielding dwarf basmati variety, Pusa Basmati 1, two more varieties namely Kasturi and HKR 238 have been evolved. Several lines in the advanced stages of testing combine along with high yield and quality comparable to traditional basmati rices, high level of resistance to major diseases and insect pests. The project is yet another example to demonstrate the potential of the coordinated research network. Like basmati rice, durum wheats also have sizeable export potential. Such network research efforts to improve the yield level and quality would help step up further our foreign exchange earnings.

Stability of production/ productivity

Less than 50% of the harvestable yield is only recovered in many of the crop species. Weather aberrations aside, disease and insect pests together with injurious soils contribute to such yield erosions. Genetic and other means have been successfully employed to resist/tolerate the biotic/abiotic stresses and minimise thereby the crop losses. Nevertheless, there are still several pests and diseases, against to neither there is reasonable level of host plant resistance nor chemical control measure (Table 2). There are pests/diseases that are highly mutable resulting in newer and virulent strains/biotypes. Development of resistance to pesticides and pesticide promoted resurgence add further to the complexity of the problem. Very little is known of the declining response of our soils to major nutrients. Only through concerted team effort, solutions to such problems could be found.

Table 2. Diseases and insect pests with moderate or no host plant resistance in major crop plants

Crop	Disease/pest
Rice	Grassy stunt virus-II, sheath blight, leaf folder, stem borer
Wheat	Karnal bunt, loose smut
Sorghum	Head mould, downey mildew, shoot fly, stem borer, midge
Corn	Maize stripe/mosaic virus, stem borer, corn Ear head worm (Heliothis)
Chickpea	Ascochyta blight, pod borer
Pigeonpea	Phytophtora blight, pod borer, pod fly
Groundnut	Bud necrosis, leaf miner, aphids
Sugarcane	Red rot, shoot borer, internode borer
Tobacco	Leaf curl virus, damping off, bud worm
Cotton	Bacterial blight, Heliothis (Boll worm)

Germplasm evaluation, maintenance and documentation

Germplasm forms the backbone of all AICCIPs. With a collection of primitive and improved cultivars, near and distantly related wild species, and induced mutants and cytogenetic stocks, germplasm banks provide an alternate/additional gene source to broaden the genetic base of all economic traits. Unfortunately, until now, not even one-hundredths of the potential of the germplasm in crop plants like rice could be discovered and utilized. It is estimated that India might have over 70,000 and 42,000 germplasm accessions, respectively in rice and wheat. Collections already available and being maintained at the National Bureau of Plant Genetic Resources (NBPGR) at Delhi and various rice/wheat research centres would be of no value, if their potential is not discovered and made available to breeders. In the wake of emergence of newer biophysical constraints and socio-economic needs, there is an urgent need for their systematic evaluation to identify diverse gene resources.

Isolation and conservation of resistance gene sources against varied biotic and abiotic stresses for instance, still remaining uncovered are some of the aspects that require immediate attention. Evaluation of germplasm in crops like rice even for a selected biotic stress, if restricted to one or two national centres would require more than 20 years to complete. The same job with much more precision could be done in just one-fourths of the period through a coordinated research network. Considering such advantage, screening of wheat germplasm has been initiated through an ICAR supported network. The network coordinated by the Wheat Project Directorate (WPD) at Karnal, is constituted of six cooperating centres with specific screening objectives, as illustrated in Figure 4. Similar research network for germplasm evaluation for biotic stresses in rice with 5

centres each for diseases and insect pests is being constituted with Directorate of Rice Research as the coordinating centre (Fig.5).

Organizational advantages of AICCIPs research networks

The following features of AICCIPs make them appropriate and ideal centres for coordinating the research networks.

- Uniqueness of organisational structure involving representative research institutions (State Agricultural Universities, Departments etc) from all the states.
- Adequate number of test centres representing diverse agroclimates and stress environments (Hot spots) across the country for each crop plant.
- Adequate scientific staff representing all major disciplines (multidisciplinary set up) at most of the centres.

Conclusion

While recognising that multi-disciplinary research at the level of commodity oriented institutions and multilocation evaluation at national/regional level had proved hitherto effective in our achieving the targeted agricultural production and productivity, it is increasingly realised that the approach of 'network research' involving relevant scientific and technological institutions would be inevitable hereafter for making sustainable advances. To find technological solutions to risk-prone rainfed environments and to introduce innovations in agriculture through exploratory research, for instance, already efforts are underway at international level in the form of 'research consortiums' and 'global research networks'. Taking full advantage of the vast infrastructure we have in the form of AICCIPS, it is timely and highly desirable to formulate problem specific research networks on the basis of priority, to ensure continued productivity advance on economically and ecologically sustainable basis.

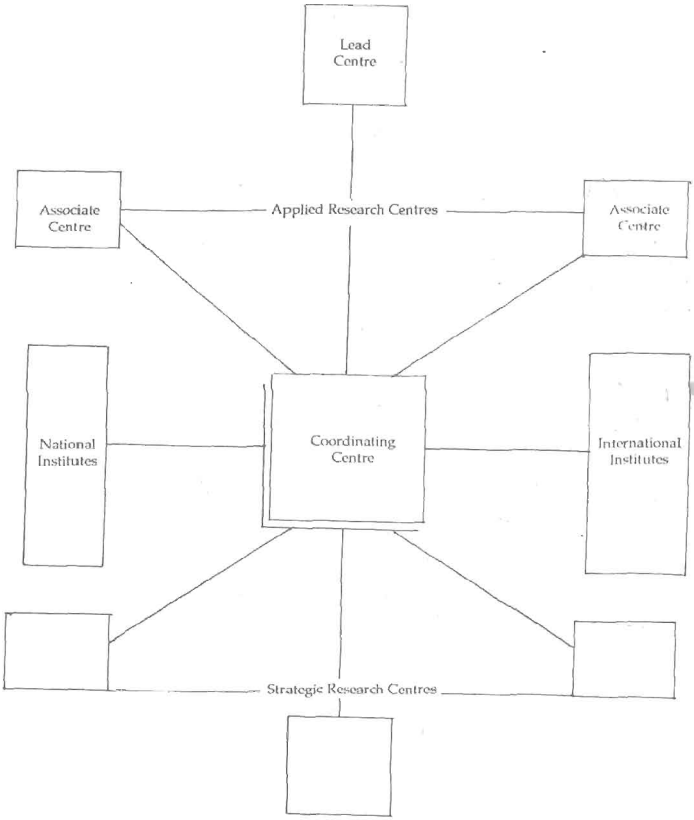
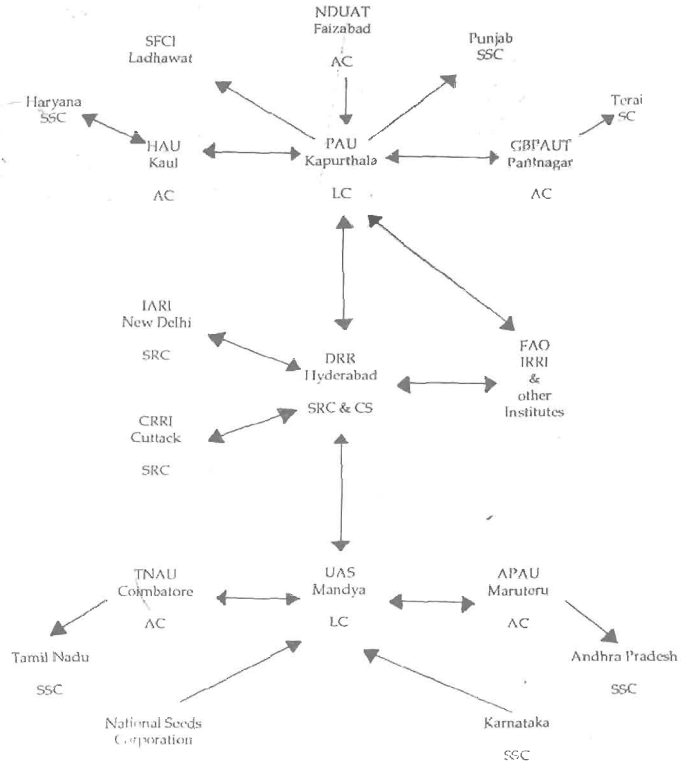
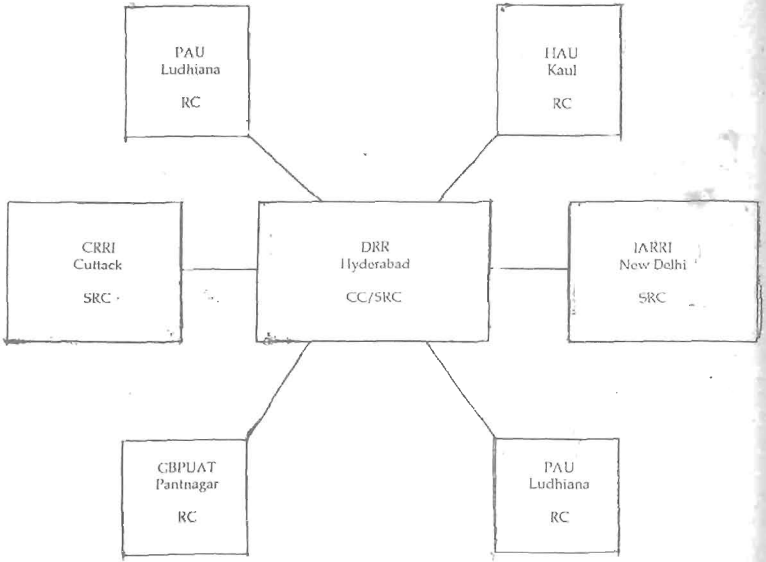


Fig. 1. Model Coordinated Research Network



LC = Lead Centre; AC = Associate Centre; SRC = Strategic Research Centre; CS = Coordinating Centre; SSC = State Seed Corporation; SFCI = State Farm Corporation of India.

Fig. 2. Schematic representation of the organizational setup of ICAR - UNDP project on development of hybrid rice technology in India



CC = Coordinating Centre; SRC = Strategic Research Centre; RC = Research Centre

Fig. 3. Research network for Development of high-yielding Basmati Rice for export

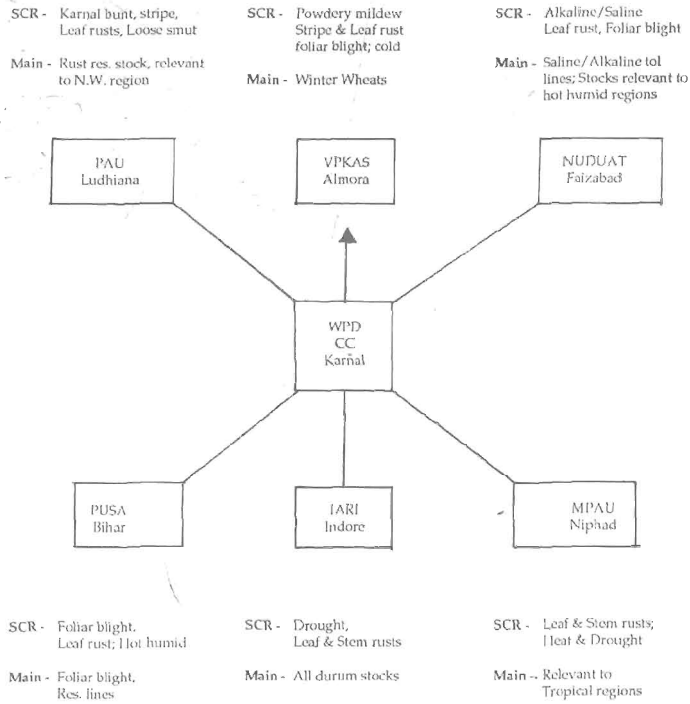
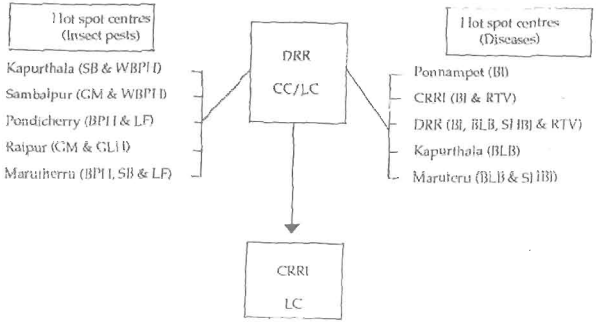


Fig. 4. Germplasm evaluation and documentation in wheat



SB = Stem borer; GM = Gill midge; WBPH = White backed planthopper; BPH = Brown planthopper; LF = Leaf folder; BI = Blast; SHBI = Sheat blight; RTV = Rice tungro virus; BLB = Bacterial leaf blight

Fig. 5. Germplasm evaluation for biotic stresses in Rice

Integration of All India Coordinated Research Projects with need based SAU Research

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The establishment of All India Coordinated Research Projects in the mid-sixties is generally hailed as one of the most significant events in the history of agricultural research and development in India. Encouraged by the good and quick results which flowed from the Coordinated Maize Breeding Scheme initiated in 1957, the ICAR started the All India Coordinated Research Projects (AICRP) for major Commodities like rice, sorghum, cotton etc and the concept was soon extended to resource based and discipline areas like dry farming, water management, soil physics, animal sciences, fisheris and home science. Indeed there was a virtual spate of projects in the seventies.

These projects were primarily designed to buttress and coordinate research activities in the states which had the responsibility to generate technologies for the farmers and fishermen in their service areas. These projects provided a fillip to agricultural research in the States[1], which was generally weak with hardly any interdisciplinary approach and multilocation testing. The AICRPs also enabled the state research institutes / stations, which were working in isolation, to gain access to the vast pool of genetic material of different crops available in different States/Universities.

AICRPs were wlecomed by all states and, indeed, some states leaned so heavily on these projects that the on going programmes at these centres suffered neglect. This is specially true in the case of crop improvement programmes as several states have either scaled down or even ceased to generate breeding material of their own in some crops as it was found convenient to obtain genetic material distributed through the projects and layout trails. Nonetheless many of the AICRPs, especially the crop improvement projects like rice, sorghum, millets and cotton have certainly helped the states to reap the benefits, through the release of a number of high-yielding varities and hybrids.

Since the mid-sixties, when the first AICRP was established, two major developments occurred which have a bearing on the working and relevance of these projects. These include :

- The establishment of Agricultural Universities by almost all the States and the transfer of research responsibilities from government departments to these institutions which, with better funding from the state and ICAR, developed research infrastructure and

[1] By mid sixties, very few states had established agricultural universities with full responsibilities for research in their respective states. Hence the AICRP in many states were implemented by the State Departments of Agriculture, Animal Husbandry and Fisheries. States, here, mean either the SAUs or the government departments.

employed a larger number of qualified scientists all of which significantly enhanced the research capabilities of SAUs.

- Regionalization of research under the World Bank assisted National Agricultural Research Project (NARP) by delimiting agroclimatic zones in the states and establishment of Regional Research Stations by the SAUs which strengthened their regional research capability and shifted the focus to the location specific problems and research planned to find solutions to these.

Thus the scenario in the States has changed considerably since the first AICRPs were established. The SAUs after same initial faltering have come of age. They are staffed with well trained scientists. Their research infrastructure is strengthened. Their regional research capability has increased. Thanks to the reorganized extention system in the states, their links with extension are strengthened.

In adequacies and incongruities in AICRPs

Thus, while the States have strenghtened their research capabilities, through SAUS and NARP, the implementation of AICRP over a period of twenty six years revealed several inadequacies and incongruities inherent in implementing centrally planned research projects to find solutions to local problems. These have been dealt in detail earlier by the author[2] and at the risk of repetition are stated below :

Inadequate appreciation of the location specific problems and research needs of SAUs

In the AICRPs, the Coordinator plays a key role in the identification of cooperating centres, their staffing, funding etc. In a country of the size and diversity of India, it is hardly possible for any person - however well informed he might be - to perceive the research needs of every situation in the country. Thus, a certain amount of arbitrariness creeps into the very planning of these projects. For instance, if a crop is grown in monsoon period and post-monsoon period in two different agroclimatic regions of the State, a single centre is located at one place ignoring the need for the other situation.

Inadequate focus on local problems in the research programmes

The formulation of research programmes of AICRPs is done at a Workshop participated by scientists from the several cooperating centres of the Project. In such a forum, location specific problems often tend to be bypassed. while the accent is on general problems. For example, if a particular pest - say white fly on cotton - is the burning problem in a state, the entomology programme of the project does not reflect this importance. Often separate experiments, outside the project, have to be planned to solve local problems. Although it is averred that the cooperating centres are free to suggest experiments to meet their needs, this seldom materialises. This top-down planning of programmes results in an inadequate focus on the local research needs. Further, the Associate Director of Research of a particular zone who is entrusted with location specific research programmes under Regional Research setup does not have much say on the technical programme of AICRP. Even

[2] Appa Rao A (1987) Linkages of ICAR with state Agricultural Universities. Paper presented at the ICAR review (GVK Rao) Committee October 9-11, 1987. National Academy of Agricultural Research Management, Hyderabad

though he feels that some of these experiments are not relevant to the situation, they are conducted because it forms a part of the AICRP technical programme. It is not uncommon to find two separate streams of research - University research and Coordinated Project research - at the same centre.

Excessive emphasis on uniformity of the experience

There is an excessive emphasis on uniform experiments at all cooperating centres. In some AICRPs the process of research is so standardised that there is a set of proforma experiments which every centre is expected to conduct. The variations in soil fertility, agronomic practices etc., are seldom reflected in these standarised set of experiments. For example, where intercropping is a rule, experiments are laid out to test varieties/agronomic practices on sole crops. Often, the concern appears to be for obtaining data from a number of centres rather than finding a solution to a specific problem or developing a practice to enhance crop yields and profitability. In breeding trails, cultures which have performed poorly in a particular location, have to be carried forward into advanced locations based on the 'average' of several locations.

Lack of effective monitoring

The Project Coordinators do not find it possible to visit various cooperating centres throughout the country at various stages of crop growth. As a result, it is not possible even to form a broad idea about the experiments. Often, the workshop reports are the only feedback he has. The Coordinator himself is often overburdened with obtaining reports from different centres, compiling, correspondence etc. There is a tendency on the part of the local managers to give secondary importance to coordinated project work.

Sub-optimal utilisation of resources - especially staff

As staff positions are created project-wise, there is a lot of duplication staffing at several centres which have more than one AICRP. For example, several scientists as agronomists are provided for cotton, pulses, chillies etc. with inadequate work for each crop are seasonal and are of short duration.

Weak links with extension

As the programme and results of AICRPs are discussed and finalised at national workshops, there is little oportunity for the local extension staff to interact with researchers and offer their views. Indeed, except crop varieties (which any way would spread if they are suitable to the farmers even when extension efforts are weak) and a few plant protection recommendations, very few technologies from AICRP reach farmers.

Flow of funds

Sanction procedures and fund releasing procedures are cumbersome. The inordinate delay in conveying the sanction and release of funds with respect to AICRPs causes a lot of inconvenience to SAUs in financing the coordinated projects. Allocation of contingent expenditure at an uniform scale of Rs. 12,000 per scientist without taking into consideration the cost of cultivation - grape and green gram are provided the same amount - is unrealistic.

These shortcomings are further exacerbated with the implementation of NARPs, which stress on location specific

research. It is, therefore, necessary to review the concept, role and functions of AICRPs - which were started when the States' research infrastructure and capability was weak - if they have to serve the States which have developed strong research capabilities and reorganised research on agroclimatic zonal basis.

Suggested modifications

There is no gain saying the fact that the AICRP - especially the commodity based projects - did deliver goods and the states have immensly benefited from these. It is also true that there is a certain degree of incongruity between the decentralized NARP approach (not to speak of FSR approach which is coming into fashion now) and the AICRP implementation. It is, therefore, necessary to review the concept, role and functions of AICRP - which were started when the states' research infrastructure, organization and capability were weak - if they serve the intended purpose.

Coordinated projects are a means and not an end in themselves. These are the means to enable the states to tailor technologies to the needs of the farmers service areas. What is the most cost-effective way of achieving this end? Are there any ways in addition to coordinated project approach to achieve this?

Any answers to these questions should also be reconciled with the fact that we were not starting on a clean slate - we have over 70 AICRP's functioning. A considerable number of scientists of ICAR and SAUs are employed in these projects. Hence any changes should be such as would not cause serious problems of redeployment of these personnel. All things considered, the ongoing AICRPs may be grouped into three categories.

- Projects which do not call for a high degree of coordination on a national scale - may be closed. Several of the specific problems based projects eg. Rodent control, Honey bees - fall into this category.

- Projects which require a fair degree of exchange of experiences, information and expertise - may be operated on a network basis. Most resource based projects like dry land, soil physical problems - fall into this category.

- Projects which require sharing of genetic material and information - to be continued as full fledged AICRPs but with an appropriate modification to remove the constraints referred to earlier and making them most costeffective. Most crop improvement projects fall into the category.

Funding

The existing funding pattern based on a fixed number of scientific and support personnel should be replaced by a system of loosely tied grants in lumpsum based on the research needs, extent of participation in coordinated / network programmes etc. and determined quinquennially by a team of experts appointed by ICAR with a provision that no part of these grants should be diverted for purposes, other than to the identified centre/programme. This would facilitate avoiding duplication of staff, redeployment of scientists working in projects likely to be closed and allocating more funds for operating expenses.

The SAUs will identify research projects/programmes which need interaction with and assistance from the ICAR, and also name the cooperators who

liaise with the concerned project coordinators/leaders. The SAUs will develop technical programmes to meet the needs of the farmers of the regions and the State. Thus the practice of developing a common programme for all centres of AICRP at the annual workshops would cease. The SAUs will indicate the staff engaged in the project/programme and the funds allocated for the purpose.

To preserve the core principle of AICRPs, the SAUs shall agree for exchange of material and information, and for participation of their researchers in the workshops held in every alternate year for interacting and to take a holistic view of the project. The SAUs will facilitate the coordinators' visits to the cooperating centres for monitoring the research work.

The arrangement suggested above will enable the SAUs to focus their programmes on location specific problems. The ICAR and the coordinators will have access to the entire field of research activities of the SAUs instead of a few specific centres. For instance, the Rice Project Director, price will be able to interact will all the eleven centres of rice research in AP AU instead of few centres where coordinated project trails are located.

Presently SAUs depend heavily on ICAR for research grants flowing through AICRPs. Any new arrangement should ensure that SAUs continue to get financial assistance at a scale not less than what they are now getting. Any abrupt changes and /or stoppage of funds to SAUs will lead to termination of services of many scientists and throw the system out of gear resulting in chaos. The changes contemplated should consider the practical difficulties likely to be faced by SAUs and the solution suggested should be implementable with least disturbance to the system.

Inter-Disciplinary Approach to Varietal Development and Evaluation

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One of the key components for the success of the country in the agriculture sector is the dynamic role played by the All India Coordinated Research Projects (AICRPs) initiated by the Indian Council of Agricultural Research. Although some amount of coordination was effected in the past in certain commodities like coffee, tea, rubber, spices, cotton etc., and subsequently by the PIRRCOM, the real coordination at the national level involving multidisciplinary teams and multilocation evaluation system became effective after the IDAR initiated the comprehensive AICRP system starting with Maize. These projects operated on multidisciplinary approach and involved the developmental departments and some times policy makers for comprehensive national approach for the improvement of a particular crop/ commodity/discipline. In the historical perspective before the All India Coordinated Projects came in sharing of materials and information as well as testing of new varieties and technologies at the national level was more a dream than a reality. After the All India Coordinated Projects came into existence, scientists working in a particular crop or commodity or discipline from all over the country irrespective of the State/Institution where they are working they came together under the umbrella of the All India Coordinated Projects to discuss on a common platform and develop a national plan for improvement of the concerned crop or commodity. This oneness of large number of multidisciplinary teams of scientists from all over the country working on a particular crop or commodity ushed in the green revolution and sustained it all these years. This model was appreciated by several countries in the world and they wanted to copy it. We have operated a number of projects whose number at one time has gone up to 85. Starting with Maize Project which came into existence in 1957, we have now considerable experience of the functioning of the AICRPs Projects and their strengths and weaknesses. With the coming into existence of 26 State Agricultural Universities with a number of agro-climatic zones and zonal approach through National Agricultural Research Project, the social and political pressures which have affected on the thinking of mission approach to some extent have affected the smooth functioning of the projects which perhaps require some restructuring and modification. The workshop conducted by the National Academy of Agricultural Research Management in November, 1985, the GVK Rao Committee report of 1988, and the Committee appointed by the Director General, ICAR in 1989 have also studied the functioning of AICRPs.

Objectives and Scope

The objectives of AICRPs are goal-oriented and in achieving the goals, it is realised by every body that the projects have to follow a multi-disciplinary

approach. In the crop improvement programmes the farmer wants varieties/ hybrids which combine high yield with adaptation, required quality, resistance to different biotic and abiotic stresses with different maturities to suit his cropping systems. To give this type of material to the grower it is absolutely necessary that teams of scientists of different disciplines work together. This is particularly becoming important with modern agriculture where there is quite an awakening among the farmers and who put pressure on scientific system for appropriate varieties to meet different market forces, both internal and external (eg. medium staple cotton - when the country wanted medium staple cotton, the scientists in the cotton project immediately responded and produced a number of varieties and hybrids with the required quality and met the requirements of the industry). The days are also gone when a single dominant personality or a discipline used to take all the credit for the work done by group of people. There are demands of different people for credit, publication and recognition. There are also pressures that the projects should not be the monopoly of a scientist specialising in particular discipline, but it shoiuld be open to anybody irrespective of discipline, of his specialisation but having managerial qualities. The State Agricultural Universities (SAUs) which were non-existent at the time of initiation of some of the projects have now become strong and with the exphasis on regional and zonal approach, the linkages between the AICRPs and the programmes are sometimes not in conformity with the requirements of the zone or a region. Some times there are delays in moving of the materials from the few centres of the AICRPs in a State to the large number of zonal and regional centres before a decision on the release of a variety/ hybrid is taken in the State. It is also experienced that the type of dedication and mission approach which used to guide the programmes in the past is diluted due to various reasons and we have different types of experiences in different projects. Although a number of experiments and trails are decided in the all india workshops, but the story of number of trails conducted and the data reported sometimes is very disappointing in several projects. The coefficient of variability in several experiments/trails is such that the data are no more acceptable particularly under rainfed conditions. There is some confusion also in the data and relationship between multi-disciplinary crop projects and the individual discipline-oriented projects. The linkages between the crop projects and the extension and training programmes are also weak in several cases. Added to this the frequent change of staff at many centres in the States is also responsible for poor performance of some projects and the continuity is lacking. There is confusion with regards to thrusts in All India programmes vis-a-vis zonal programmes and programmes of SAUs. There are communication gaps as well as sturdiness in exchange of information and materials. The off-season nurseries which have been initiated in some crops are not receiving the materials for growing in the same way as they used to in the past. In some cases, the team spirit is lacking weakening the programmes and the goals and there is undue reliance of materials generated elsewhere. There are many more weaknesses which the AICRPs are experiencing.

Case study

Wheat

The All India Coordinated Wheat Improvement Project was hailed to be one

of the most diversified and biggest programmes in the world. It was mainly responsible for ushering in and sustaining the wheat revolution in the ICAR and SAUs and some voluntary organisations. In the project there are number of main centres and also subcentres. All the main centres multidisciplinary teams of scientists involving mostly the disciplines of breeding, agronomy and plant pathology are operating. In some centres particularly at the zonal centres, the disciplines of physiology, quality and engomology are also located. The responsibility of the breeding group is to generate variability and select for desirable traits. Most of the work involved inter-varietal crosses and in some cases inter-specific crosses. The pathology group used to get initial inoculum of the rusts from the Flowerdale Laboratory, Simla or the Rust Research Laboratory, Mahabaleshwar and multiply it and inoculate the breeding material and nurseries. They also used to screen materials against other pathogens. Sometimes the pathologists used to go out and collect inoculum from different farmers' fields and also use it for rust inoculations. They used to systematically inoculate the border rows in the evening and also the actual breeding materials. Excellent epidemics were created which facilitated selection for resistance. The promising breeding stocks and advance lines in trails were also screened against individual pathotypes under glass house conditions. The agronomists used to take the advance promising lines of the Stations or those which are in the all India coordinated advance trails and evaluate them under different dates of sowings, different levels of fertility and different irrigation regimes. They also used to conduct experiments of weed control, micro-nutrients and with the help of the quality group used to evaluate the the effect of different agronomic practices on quality of grain. The physiology group used to conduct drought screening and other nurseries at the all India level and also identify parameters to help select better genotypes and segregants. The entomology group used to screen the promising materials against both stored grain pests as well as field pests and guide the breeders in developing varieties which are less affected by the pests. The nematology group used to screen materials against "molya" and "tundu" diseases. The quality group both at the headquarters of the Project Directorate as well as the zonal centres systematically screened the IET and UVT materials as well as germplasm for different quality parameters for chapathi/bread/biscuit and other products making. The result of this multi-disciplinary team approach at different centres of the project help to evolve a number of varieties and technologies which are responsible for the wheat revolution. There used to be very heavy demand on the off-season nurseries at Wellingdon and Lahaul. The breeders and pathologists used to visit these nurseries to screen against diseases, besides advancing generations and taking up initial multiplication or promising materials. The all India workshops used to be a lively, aggressive and thought provoking.

Over a period of time this multi-disciplinary aggressive team approach gradually started showing cracks. With the exception of few centres, one does not find its team approach in achieving the goal of producing high yielding, disease and pest resistant, high quality variety with particular or specific adaptation. Team approach at many centres is giving way to individual or individual project approach. This change may be due to a number factors but this is not good for achieving the goals for which the AICRPs are initiated.

Betal vine

Betel vine is an important commodity in the country both for internal use as well as for export purposes. Trade involving several hundreds of crores is dependent upon this commodity which is directly consumed by humans. The crop is attacked by certain important diseases. While the answer is to produce varieties which are resistant to diseases through breeding, introduction and evolution and also need based application of minimum quantities of fungicides as the leaves are directly consumed. There was very little thrust on finding solution to this problem this in the past. Similar was the case with agronomic management. A multidisciplinary team of scientists would have helped to improve this crop and its productivity in its totallity than an individual discipline-oriented approach.

Pulses and oilseeds

These two groups of crops in the All India Coordinated Oilseed and Pulses Improvement Projects did not receive as much thrust as individual crop-oriented projects, in view of the large number of crops in each group. The multidisciplinary teams in the classical sense could not be effectively remain except in a few major crops. If these crops are to make progress, they have to be looked in individually as in the case of rice and wheat. To give the much required thrust, to quote from the report of the Directorate of Pulses Research in this group meeting : "The present structure of organisation has led to individualistic approach with the scientists of different disciplines remaining aloft to inter-disciplinary research. Hence there is need for crop based groups/conditions constituting of scientists from different disciplines with a feeling of team spirit".

Conclusions

The country is heavily dependent on agriculture. There are number of challenges for increasing total production of different commodities, increasing production per unit area, development of varieties suitable for different cropping systems and farming systems, reduction of losses from different biotic and abiotic stresses, improvement of quality of the produce and also promote exports and be competetive in the international market. With these challenges before us it is important that in each AICCIPs emphasis should be given to achieve the goals of the country and for achieving these goals there is no other way except to follow multi-disciplinary model for varietal development and evaluation. At every stage of AICCIP's, there is a need to look at the whole issue in totality rather than from the view point of individual, discipline or excellence. The multidisciplinary approach should be instilled from the very beginning of the project preparation and its execution through breeding, evaluation and ultimately release to the public. If this approach is not followed, it will mean halting progress and the country has to pay a very heavy price for parochial approach.

In my association with the AICRPs at one of our premier institutions which has a large number of scientists in each discipline, I posed a problem on how to produce a highyielding pest and disease resistant good quality variety with wide adaptation and also dwarf stature responding to input application. This is the type, the farmer is anxiously looking for. Since at these institutions people are individually looking at their own disciplines and also breeding varieties for a specific condition the answer to my main question which is the type of

material needed by the farmer there is no answer. This underscores our lack of team work and lack of appreciation of the goal for which an institution or a project has been created.

While ICAR with its pattern of funding of 75:25 basis cannot support large number of centres in the country with the multidisciplinary teams of people, it is necessary to re-evaluate whether we require so many centres with the limited number of disciplines or whether we can have few major centres representing different agroclimatic zones and strengthen them strongly on multi-disciplinary teams of scientists with the needed facilities. To support such system a number of pre-requisities are needed (a copy of the letter addressed in July, 1982 from ICAR addressed to different crop Coordinators is relevant and there are many more things to do besides what is indicated in the letter) for a successful implementation of a multi-disciplinary approach. The basic components are (a) clarity of the goal to be achieved, (b) flexibility and dynamism in the programme with the changed pattern of agriculture and thrusts of the information, (c) good teamers in the multi-disciplinary team (individually a person may excel in science but if he is a poor teamer, he can be more problematic than helping to achieve the goal). Certain amount of freedom to operate for indibidual scientist within the framework of the objectives. (d) Needed amount of facilities to operate, (e) Ability to rise to manage a crisis in the crop scenario, and lastly (f) sense of discipline and high dedication. There should be a keen approach and time frame. In addition, the decision on crop technology releases should be based on the data on multidisciplines and also based on agro-ecological requirements of a specific area. There is a need for the Project Directors and Coordinators to consult SAUs with regard to staffing. Sometimes when the multi-disciplinary staff is provided, their work is only season bound. There is a need to explore the possibility of making these teams of people to work on another crop/commodity in the lean season.

There is a need for drawing strength from the discipline-oriented All India Coordinated Projects in Agronomy, Soil Science, Nematology, Entomology, Weed science etc., to strengthen the crop based projects. While these discipline-oriented projects may go in depth into the basic issues and found solutions, the applied aspects could be tested in the crop oriented projects for verification in the multi-location trails all over the country. This type of approach will compliment each other in achieving the national goals in a shorter period. Similarly, in the area of wide crosses involving different species and genera, AICRPs could give goal-oriented programmes to scientists specialising in genetics and cytogenetics and other allied disciplines and draw the knowledge in developing strategies in achieving the goals of the project. In conclusion, if the AICCIPs have to deliver the goods they have got to be multi-disciplinary in nature and ICAR should foster the team spirit of scientists of different disciplines working all over the country through these projects.

The AICRPs also will gain stature if certain centres and scientists outside the ICAR system are strong in particular subject or discipline if they are given certain responsibilities. They can add to the strength of the project as a whole. Similarly, a time has come for the ICAR to look at the AICRPs centres at its own institutes which now come under non-plan. It is well known that once the project centres in the ICAR instituttes come under non-plan, they do

not actively subscribe to the AICRP and carry on the allotted work in the workshops.

In India with different soil and agroclimatic conditions there is always a crisis in crops either due to pests and diseases or rain fall aberrations or soil problems. Also there are compelling reasons for a particular quality parameters either for meeting the local industrial needs or for exports. These issues are urgent and brook no delay or vascillation. In such circumstances it is a multidisciplinary mission and time targetted approach is needed and these can be achieved if the multidisciplinary approach is fostered in AICRPs.

ANNEXURE

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
KRISHI BHAVAN : NEW DELHI -1

DR. M.V. RAO
DEPUTY DIRECTOR GENERAL
(CROP SCIENCES)

D.O.No : 441 DDG (CS)/82
Dated the 6th July, 1982

Dear Colleague,

Every year we are holding the workshops of the All India Co-ordinated Crop Improvement on Plant Protection Projects. Some of the projects have got two workshops in a year. During the last one year I attended some workshops. There is lot of variability in the method of conduct of the workshops from project to project. I am making some observations on these workshops so that we may have some uniformity

(i) A number of recommendations are made in each workshop for implementation. In the following workshops I am not seeing any report from the Project Director/Co-ordinator on the action taken on each of the recommendations. I request that as a policy, the Project Director/Co-ordinator should read out the recommendations of the previous workshop and indicate the action taken on each one of them, in the inaugural session itself. If some people have not taken action on the recommendations this should be clearly spelt out so that we could draw the attention of their superior officers.

(ii) Similarly, the Project Director/Co-ordinator should indicate lapses, if any, in the implementation of programme by any of the centres whether it is a state, centre or ICAR centre. Since ICAR and the State Governments are spending considerable amount of money on research, we are duty bound and are accountable for proper implementation of the programme. If there are any non-performing centres which are not conducting the experiments well and giving one excuse or the other, they should be named in the workshop. Some of the centres may not be conducting the experiments properly over a period of time. If this is so there is no point in spending money on such centres. Their performance should be reviewed and if there is no scope for improvement, you may recommend withdrawal of our support. I am also seeing that some centres are not sending their reports to the Project Directors/Project Co-ordinators. Attention of the appropriate authorities should be drawn on this lapse.

(iii) The Project Director/Project Co-ordinator's report which is presented in the inaugural session should cover the progress and implementation of the programme as well as the crop and weather conditions during the season. The report should cover the salient results of different experiments of

different disciplines. This report in a way should serve as a summary Annual Report of the project.

(iv) Where data are involved the Project Director/Project Co-ordinator should see to it that the duly analysed data are despatched to the participants at least one week ahead of the workshop so that they come fully prepared to the workshop. This is necessary and imperative for useful and constructive dialogues.

(v) In the workshop, decisions should be taken on identification of varieties for minikits/adaptive trials/pre-release multiplication if they have completed their required number of tests. A varietal identification committee, consisting of experts who are not directly involved with the testing of varieties/technique may be constituted and invited to the Workshop to help the Project Director/Project Co-ordinator in the identification of varieties. The Project Director/Project Co-ordinator and his Principal Investigators should be ready with all the information covering different seasons and disciplines, to assist the committee. The committee may be constituted in consultation with the Deputy Director-General and Assistant Director General. The results of the identification Committee should be announced in the workshop.

(vi) We are often criticised that some of our workshops are becoming ritualistic and that there is no proper discussion, interaction and seriousness. Some of the invited participants are only silent and passive spectators without making any contributions to the workshop. Ove a period of time, our Project Director/Project Co-ordinators would have observed that some participants, whose participation does not contribute much to the workshop. Such cases may be considered while preparing the list of invitees. The purpose of the workshop is very serious for taking stock of what has happened and plan the next year's programme. In the workshop, we also have to give guidance and valid recommendations wherever we have proven results, to the developmental agencies.

(vii) While preparing the agenda of the workshop, the topics in each session should be clarly indicated and the speakers against each one of them named. Many times I am seeing that only topics of the session are indicated without the names of speakers. This type of agenda leads only to a very general discussion and does not promote well directed, intensive discussion. If the speakers have to report on results of experiments conducted, they should be given sufficient time and the data to prepare and present the report. This means the analysed data should be in the hands of speakers well ahead of the workshop. This requires advance planning and, I am sure the Project Director/Project Co-ordinators who are the Kingpins of the whole programme would be able to organise the whole thing in a systematic manner.

(viii) The proceedings and recommendations of the workshop should be finalised and despatched within few days after completion of the workshop. Every effort should be made to present final programme in the plenary session. To my surprise I am seeing in some of the workshops, the programmes and experiments being chalked out in the plenary session.

(ix) The Project Director/Project Co-ordinator should move from Centre to Centre in the crop season and monitor the work. Unless the Project Director/Project Co-ordinator visits different centres and share his experience and knowledge and understand difficulties of his colleagues, the programme will not have the needed dynamism and tempo. Visits to the centres enables us also to monitor the staff vacancies, utilisation of funds, etc. Wherever, posts are lying vacant, attention of the appropriate authorities should be drawn. I am sure that as leaders of these All India Projects, you will continue to inspire your fellow workers and guide the programme.

(x) Besides the sessions dealing exclusively with the project work, we should have a session on topics of basic nature or on topics of immediate or future relevance. If necessary appropriate speakers may be specially invited to give talks.

(xi) The Directors of Agriculture of States and representatives of any pertinent development agency should be invited for the workshop. One session may be devoted for the presentation of reports by the Directors of Agriculture. Their participation will greatly help in understanding the problems of each other to find solutions.

(xii) When a variety is proposed by a breeder in the workshop, there should be a minimum quantity of seed (that is decided by the experts) of that variety/inbred lines/composite/synthetic should be available with the breeder. If that much quantity is not available inbred lines/composite/synthetic would not be considered. This necessitates advance planning at least one year ahead by the breeder.

(xiii) At each workshop a package of practices should be prepared and finalised for passing on to the Extension Agencies. In non-crop projects any information of extension value should be given out for wide dissemination.

(xiv) Immediately after the workshop a press note should be prepared for release by the ICAR Headquarters.

(xv) A concise report should be prepared after each workshop for the Union Cabinet giving the salient results and, sent to ICAR Headquarters.

(xvi) In some projects no zones were indicated based on soil, agro-climatic conditions, disease and pest complexes, maturity requirements etc. Common sets of varieties are tested all over the country and only those varieties were considered for identification/pre-release/minikits which have done well all over the country. Because of this approach in some projects no varieties could be released even though some varieties did well in groups of states with similar soil and climatic conditions. If the zones are not formulated already it is necessary that they are formed forthwith in consultation with the Director of the National Bureau of Soil Survey and Land Use Planing, Nagpur, meteorologists, pathologists, entomologists, nematologists etc. The zones should be throughly discused, if not formed already, in the workshops and finalised.

(xvii) At no time the plant material is moving so much from one corner of the country to the other as it is now with the coming into existence of AICRPs. While we want a free exchange of material from state to state and zone to zone, we have to be cautious about transmiting pests and diseases from one area to another. This is particularly so in vegetatively propogated materials and to some extent with the seed materials. Caution and discretion is to be exercised in formulating trials/experiments so that we do not consciously spread the diseases/ pests/nematodes from one area where they are prevalent to another area whether they are not known. Zoning of the country assumes particular significane in the context. While organising National trials precaution should be taken, if necessary, to treat the plant material before sending, with appropriate chemicals.

(xviii) In some projects multiplication of plant and seed material is not considered as an important activity. Varieties are identified, pre-released or recommended in the workshop, but no arrangements are made for their multiplication and population. If there are no proper arrangements or system for multiplication of plant or seed materials, this should be brought to the attention of the concerned ADG and the DDG.

The Project Director/Co-ordinators has to often advise the Seed Agencies whether it is NSC, SFCI or State Seed Corporations on the areas where seed multiplication may be taken up. Although from commercial angle, seed multiplication in certain areas would be more advantageous, profitable and convenient than others borne from the disease/pest/nematode angle they may not be the best. If there are tuber/seed diseases etc., in the multiplication areas the seed agencies should be advised to shift the

seed/tuber and other plant material multiplication work to areas where these pests/diseases nematodes are not present. If this is not done the pests and pathogens will spread all over the country.

(xix) It is noted that in some projects hybrids/composites/synthetics/varieties are tested in the All India Co-ordinated trails for 6 or 7 years without taking any decisions. This is unfortunate and should be avoided. Normally a variety enters the initial Evaluation or Preliminary trails of the All India Co-ordinated trails after it is evaluated by the concerned breeder in his station trails. In the All India trails the merit of the variety/hybrid/synthetic/composite should be known within three and a maximum in rare cases of four years. A decision should be taken after this 3 year period what to do with it. The decision should be guided not only by yield and adaptability but should also be based on multiplication data on agronomic superiority, resistance/tolerance for different pests/disease/nematodecomplexes, quality characteristics etc. The ultimate decision on the future of the variety/hybrid/composite/synthetic/clone etc., should be decided and announcement made in the workship itself.

(xx) In project where work is concerned with a number of crops as in the case of fruits, pulses, oilseeds etc., or in plant protection projects it is not necessary that every centre of the project should work on every crop or pest or pathogen. Centres should be identified to work exclusively on one or two crops or few pests and pathogens depending upon their importance in that particular region. This obviates dilution of work and facilitates concentration on selected important crops or problems of the region.

(xxi) As every crop improvement programme depends on genetic variability every effort should be made to get, may be specifically identified to maintain the germplasm. Wherever good material is available in the world, we should endeavour or get it through NBPGR.

(xxii) Zonal meetings/group meetings during the crop season wherever necessary may be organised with limited number of scientists to study and interact on field problems. Once in a while a national seminar/symposium may be necessary to discuss all the basic aspects and future problems.

You will kindly appreciate that the All India Co-ordinated Projects are very crucial for the economy of India and for harmonious conduct of research in the country. By spirit and definition and Co-ordinated approach is a form of organised cooperation in which the Project Director/Project Co-ordinator has to play an important role of uniting all the scientists, giving a sense of direction and thrust to the programme and in delivering the goods for the benefit of the country. Everybody in the programme looks to the Project Director/Project Co-ordinator for his knowledge, impartiality, guidance, inspiring capacity and outright dedication to the cause of his project. Successful Project Directors/Project Co-ordinators are these who command and not demand respect of his colleagues. Similarly, successful projects are those which could deliver the goods for the benefit of the society.

I thought I should share with you may views on running the All India Co-ordinated Projects of the Crops Division. I am sure you will give appropriate attention to the points I mentioned here. I welcome any further suggestions from you.

With kind regards,

Yours sincerely,

Sd/-
(M.V. Rao)

All Project Directors of Crops Division, All Project Co-ordinators of Crops Division, Directors of Crop Institutions, Director-General, ICAR, ADGs of the Crops Division

Technological Change and its Management in Relation to All India Coordinated Crop Improvement Programmes

N.G.P. Rao

Agricultural Scientists Recruitment Board, New Delhi

The Initiation of All India Coordinated Crop Improvement Projects (AICCIPS) during the mid and late - sixties was an important innovation in our agricultural research system. Most of the projects have now completed 25 years. A review at this stage is appropriate to provide a new direction, set research priorities and bring about needed structural changes to render the projects respond to the emerging needs and situations. This attempt is a conceptual exercise in that direction.

The context for change

AICCIPs furnished the main stay for the high-yielding varieties technology and the green revolution largely responsible for the advances in foodgrain production, food security and national food self-sufficiency. In spite of this most significant contribution on the agricultural front, the green revolution technology which has been selective, raised questions of equity, stability and sustainability. It has created certain amount of disequilibrium in agriculture. The energy intensive nature raised issues of ecological and economic vulnerability. Growth with ecological and economical sustainability has become the primary concern.

To day, within the research project experimental yield plateaus are commonly encountered. A sense of technological stagnation pervades the project system.

The national research system has undergone vast changes; the expansion of the state agricultural university (SAU) system; investments in the national agricultural research projects oriented towards regional research; the growing collaboration with the international research centres of CGIAR; the advent of private research including multinationals leading to corporatisation of agricultural research; considerations of the intellectual property rights (IPR) for crop varieties, hybrids and genetically engineered plants; and the trade related intellectual property rights (TRIPS). All these have a bearing in chartering the future course.

In advanced countries, genetic engineering and biotechnology are receiving greater attention and there is a race to own the biological and genetic ingredients of agriculture. Production systems are moving towards high technology and there is growing centralisation and coupling of plant genetic power with corporate power. The need for change, the need for a different technological paradigm, both cognitive and institutional is imminent in shaping the future of AICCIPs.

Science, technology and technological change

Science is a continuously replenishing reservior of knowledge from which

technology draws the necessary quantum to provide for increasing amounts of economic output and acts as a propellant for economic growth (Clark 1987).

If agricultural growth is to continue to be based on intensive use of inputs, very little will be available to improve the welfare of rural communities or to transfer to the rest of the economy. The incentive to produce in the face of rising costs must be met by technological change and not by increase in prices and subsidies. Prices are indicators and not solutions to problems of agricultural production. The answer lies in technical change.

Agricultural production must increase from advances in resource productivity. In any optimal growth strategy, a dynamic relationship between agriculture and industry should be established. A dynamic agriculture should provide an effective demand full for growth in other sectors and should provide for employment growth. The capacity to foster diversification in agriculture must be acquired and steps towards sustainability of agricultural growth are essential. In the long term, concern of ecological and economic sustainability will lead to the weaning away of marginal and unproductive lands from agriculture to forestry and other activities. Consequently agricultural production must come from a smaller cultivated area and from a progressively reducing labour force. A technological change is a change in the production function which relates inputs and outputs to produce more with less. The productivity gains are with respect to space (area), time, investments, resources and manpower. The direction of change, its rate, pattern and pulse determine the magnitude of the change.

The basic pattern of a technological change, effort vs. performance, takes the shape of an 'S' shaped curve. When the top of the 'S' curve is reached progress can take place only with the introduction of a new technological concept and consequently a new 'S' curve is superimposed on the first and this new curve introduces a path of further technological advance. The transition from one technological concept to the other is not smooth and the change over from one 's' curve to the other causes discontinuity. To live through such a discontinumity, a sound knowledge of technological fundamentals and market forces is required. If we fail to get into the next 'S' curve, we get relegated to the forgotten league of yesterday's performers' (Vanwyk 1987). Agricultural research in India has reached a stage that unless we get into the next 'S' curve, stagnation results.

Robustness, its value as an agent of social validation, the economic interest it generates, the availability of alternatives to deal with pitfalls are important elements of new technologies and technological change (Clark 1978).

The green revolution technology: Gains and limitations

In spite of climatic fluctuations, the seventh plan target of nearly 175mt of foodgrains has been accomplished. Agriculture during the last two decades acquired greater resilience to climatic aberrations. Thus the post- independence and post - green revolution era witnessed substantial production increases in cereals, edible oilseeds, pulses, sugarcane, cotton, potato, vegetables, etc. (Tables 1, 2). Food self sufficiency, decline in poverty levels in States with assured irrigation, improved economic viability of medium holdings, enhanced investment opportunities in agriculture are significant positive features.

On the negative side, areas lacking irrigation facilities generally lagged behind and the benefits tended to reach select groups only. There have been considerable intercrop, interstate, interdistrict and farmer to farmer variations in technology adoption and the consequent benefits. Per capita food supplies and the nutritional status did not rise. Employment growth rates lagged behind population growth rates. Crops with low income elasticities of demand occuppied a diminishing share in cropped area. Increased input costs and demand - supply factors have affected cost benefit ratios. Subsidies on input costs are on the increase. Yield improvements do not seem to have fully compensated for the declining thrust in area. Excessive and irrational use of irrigation, chemical fertilisers and pesticides have raised questions on pollution and the long term sustainability of agricultural growth and resources.

The over all production rose and so the financial and economic dependencies.

AICCIPs : Organizational advantages and drawbacks

The genotype x environment interaction approach to crop improvement has been the rational basis for the multidisciplinary AICCIPs with a crop or a commodity oriented research. These projects enabled for annual discussion of problems and programmes, free exchange of germplasm and breeding materials and a multilocational, multiyear testing which provided for rapid identification of varieties/technologies and distribution of benefits with reasonably rational use of resources.

The earlier philosophy of breeding for adaptation to narrow ecological nitches with narrow germplasm base and marginal yield advantages gave place to use of diverse genetic materials for wider adaptation and quantum jumps in yields and stability. Our horizons on adaptation, germplasm, breeding and testing methods, and yield levels have certainly expanded. The first improved high-yielding varieties of wheat and rice, and hybrids of sorghum and bajra in drylands are examples of this kind. The technology certainly reflected robustness (Rao 1991).

While their immediate dividents were spectacular, later progress has been slow; the operations became some what mechanical and ritualistic. There has been a feeling of stagnation and the States started feeling that AICCIPs took away the individual initiative with consequent setbacks; the heavy load of coordinated trails was cited as a factor. The emphasis on varietal releases or technological packages and the reward system for such efforts affected basic and strategic research. There have been conflicts between State and central releases and large number of releases with few accepts. There have also been accusations of bias, prejudice and malpractice.

As the programmes expanded, AICCIPs were organised on zonal basis - agroclimatic or geographical. Zonal coordinators were identified and crop improvement, testing programmes and release recommendations were largely confined to the respective zones. Analysis of wide vs. zonal adoption with respect to several crops - wheat, rice, sorghum, bajra, maize and mustard - revealed that the proportion of variation for yield accounted by the zone x genotype interaction accounted for a small fraction (less than 10%) of the total variation (Rao 1991). This does not apply to special situations like adverse soil condition, hot sopt situations, diverse seasons etc which

need special attention. The studies indicated that the zonalization in several instances was arbitrary. Consequently zones with limited number of test locations placed limitations in identifying large and significant yield differences along with broad based resistances. In spite of several zonal releases, widely adapted varieties continued to be cultivated across zones.

Another important factor limiting release recommendations is the near absence of data from adaptive research trails carried out under-on farm conditions with participation of research, extension and farmer groups. The minikits and various kinds of demonstrations no longer emphasize data acquisition. Operational research projects are few in number. The data base for release recommendations, all India or zonal, had limitations.

It is, therefore, necessary to bring a balance between the need for identification of robust technologies through wide testing and develop appropriate practices for local adaptation through location specific and on-farm research. This necessitates a relook at the testing network and the trial mechanism to better serve the purpose of adaptation, varietal releases and location specific research for developing cultural practices (Rao 1989).

Technology generation : Alternative paths

Future Indian agriculture will continue to be varied from the oldest and simplest of organic methods to the highest technologies. Productivity releated programmes dominated the research agenda of the crop improvement projects. Sustainability, competitiveness, environmental concerns, biomass and renwable energy sources and processing related attributes should additionally constitute the research agenda for future crop improvement. The alternative paths to change are briefly considered.

Modifying green revolution technology

The first course is to continue the current trends of green revolution technology in assured irrigated situations incorporating greater levels of resistance to biotic and abiotic stresses, enhancing input use efficiency and reducing pollution effects by judicial management of inputs. It will be necessary to identify and quantify the adverse effects of input use and initiate studies to mitigate adverse effects. Cost escalations and disparties are likely to continue under this approach.

The vast majority of the dry lands not touched by green revolution will benefit by some of the components of HYV technology, particularly high yielding varieties, limited fertiliser and pesticide use and cropping system manipulations (Rao 1991). This is essential to step up the productivity of this large dryland belt. The projected watershed based technology for the semiarid areas is not only cost intensive, but its inherent limitations have been well brought out by Walker and Ryan (1990). Immediate solutions to yield increases will apparently be found in judicially manipulating some of the components of the HYV technology incorporated on the basis of cropping systems.

Data base for sustainable agriculture

The concepts governing sustainable agriculture include : (a) economic concerns; (b) environmental concerns; and (c) public welfare concerns. The degree of their integration in horizontal, vertical and time dimensions sets apart the sustainable

agricultural approach from the more conventional approaches. Since agriculture involves site and situation specific processes, it is not possible to define sustainable agriculture in terms of specific sets of practices (Weil 1990). The terms, biological, ecological, alternative, regenerative and low-input sustainable agriculture (LISA) have been used in the same context.

"A sustainable agriculture is one that, over the long term, enhances environmental quality and the resources base on which agriculture depends, provides for baisc human food and fibre needs; is economically viable; and enhance the quality of life for farmers and society as a whole".

The principles underlying low-input sustainable agricultural systems are; (1) adapting the agricultural system to the environment of the region, including soil, water, climate and biota present at the site; and (2) optimising the use of biological and chemical/physical resources in the agro-ecosystem. Data is now forthcoming that high yields could be maintained and input costs reduced by adaptive management (Piementel et al. 1989).

Integrated pest management (IPM), biological diversity, crop rotations, optimising biological interactions in the soil, animal integration - each form a part of an integrated knowledge system behind this concept.

The concept is being put into practice in advanced countries affected by intensive use of inorganic inputs and data on its utility are emerging. In our country we are yet to develop an organised experimental frame work and generate data. AICCIPs are well placed to design suitable integrated research projects in site specific situations and generate data before adoption. Such studies need to be carried out under on-farm situations rather than on experimental farms, which in many cases ceased to be representative.

Agricultural biotechnologies

Agricultural biotechnologies and genetic engineering based on genes, microbes and molecules have the potential to be safely and beneficially applied for improving food production, environmental quality and agricultural diversity. There is the possibility that some of the technologies might go wrong - cause ecological and economic problems, reduce genetic diversity, and may have ethical and social consequences. Some of the developments in the offing are discussed.

- Development of new crops which would not require pesticides, make better use of ecological pest controls, make their own fertiliser, use less water, result in reduced costs and expanded choices. They offer vast genetic opportunities and optimal benefits to farmers, consumers and environment. Greater investments in crops used for food processing, energy crops and biomass as it may be more economical than process manipulation.

- Plant growth regulators may enable plants to stand drought, cold, heat etc. Pesticides, fertilisers and microbial products are being designed to work with certain kinds of crops matched to individual genes as in the case of herbicide resistance. The range of product possibilities that might match the genetic instruction with an outside chemical

or microbial product is potentially limitless. Computers have replaced test tubes to generate new chemical structures with expected biological effects. The combination of computers, genetics and chemistry is building integrated packages of chemical, genetic and microbial ingredients in agriculture. The integration of plant growth regulators, biotechnology and plant breeding offers tremendous opportunities.

- With better understanding and growing control of differentiation of plant cells, it has become possible to produce anything that we could get from grain, fruit, nut, vegetable and even fibre. Advances in tissue culture research have enabled sprouting of juice vescicles directly without the culture turning into a callus by using the right medium and right nutrients. Orange juice from juice sacs grown in culture, fabrication of new flour without wheat, corn or any grain have all been accomplished in the laboratory and are in the mass production stage. Artificial products of real food - bioprocessed food - as a supplement to conventional production is now in the realm of realization and may yet provide a different food security mechanism (Anderson 1990).

- Single cell protein (SCP) from microorganisms extracted from dried cells, the production of SCP from natural gas, soybean endosperm from tissue culture are opportunities for a factory model protein production.

- With the advent of biotechnology, there have been large scale take overs of seed companies, agrigenetic companies by multinational oil and chemical companies who have made tremendous investments. About 20 to 30 large corporations are likely to dominate agricultural biotechnology. Food production is getting transformed into a high tech international business. Biotechnology has facilitated the trend towards centralization of food production. Agriculture could be in fewer corporate hands (Doyle 1987). The role of public sector research in this context needs analysis. Public sector capability in these areas should be built up not only for promoting contemporariness in science and for training purposes but also to assimilate the developments to face emerging challenges.

Strategic and basic researches

The absence of components of strategic and basic research renders projects and programmes, sooner or later into routine ritualistic exercises. Society reacts to *demographic and economic forces, and* developments that result from exploration. The dynamics of agriculture are constantly changing.

It is, therefore, necessary that the approaches, results, methodologies, farmer reactions, demands, changes in the social and economic situations are constantly analysed and suitable strategies developed. As examples, what are the alternate strategies to minimise pesticide use in cotton? What are the reasons for the experimental yield plateaus encountered in case of several crops and what germplasm resources have the potential to elevate yield levels? What are the additional opportunities to enhance pulse and oilseed

production if genetic limitations do not permit yield advances? Is the productivity of the vast Indo-gangetic belt during kharif satisfactory and if not what are the opportunities? If there are advances in yield in early maturing rice varieties, how could this be taken advantage for diversifying the rice based systems? What could be done to enhance the productivity with assured rainfall, in black soil belt. If rabi jowar performance is consistantly low and fluctuating, what could be alternative approaches to stabilise production? These are only some examples for strategic research and possible solutions or alternatives could emerge only from well planned studies. Similarly certain amount of basic research oriented towards materials and methodologies is essential to keep the projects vibrant.

Institutional and structural changes

Science coupled with commerce is emerging as a shaping force in the society. The geopolitics of agricultural production, trade and distribution are being transferred by the new agricultural technologies. A particularly foreboding trend, was an evolving shift in the control of agriculture; a shift that was inexorably moving farmers and natural resources out of the picture and bringing non-farm corporations, technology and international politics into the picture (Doyle 1985). Patenting and commercialization of new biotechnologies and new business strategies are visible. The concept of public sector research and private sector application is disappearing. University-industry collaborations are being fostered and biotechnology facilities are created under the joint auspicies. New technological knowledge has to be shared and the increasing number of alternatives explored for public good.

The institution of AICCIP has to set its institutional frame work in the context of the current national research system and growing privatisation and play a synergestic role. Its major concern should be to absorb emerging technologies from all sources, develop contemporary capabilities, promote a self reliant agricultural research system and avoid long term dependence.

Organization of Research : Three level set up

- I visualise a National Research Centre type organization for each crop where the emphasis should be on high tech research with emphasis on genetics, chemistry and microbiology with modern facilities, green house or screen house etc. Biotechnology and process orientation of the crops and commodities will be a part. This would need drastic changes in scientific personnel. The laboratories need to be well equipped. Certain amount of strategic and basic research will also be done at the agricultural universities where the respective crops are important.

- The main centres of the project in the respective States will : identify and quantify the hazards of green revolution technology and work for their amelioration; undertake research including on-farm, on sustainable agriculture, develop an expermental frame and data base; and also undertake some basic and stategic research.

- Conduct on-farm adaptive research with participation of researchers, extension personnel and farmers.

Testing network

- In view of the limitation of the zonal aproach and since the State is an administrative unit, a three stage testing network is visualised.

- A reasonably representative all India testing network (where the crop is important) with support of hot spot locations to identify distinct varietal differences and broad based resistances. The load of all India trials should be kept at the minimum so as to enable state level scientists to pursue reserach interests.

- A more extensive state-wise representative testing network where the locally developed varieties along with the best identified in the all India mechanism will be tested.

- Adaptive research with participation of researchers, state level extension agencies, farmers, farmer organizations and voluntary organisations. Participation in testing will be from all agencies, central, state, private and international.

Joint ventures in research

In high tech areas where investments are high and with reference to solution of specific problems encountered, joint funding and operation will be beneficial even though academic freedom in the public sector and corporate secrecy are areas of conflict. There are yet areas and problems that need scientific solutions. Such joint ventures help in resolving conflicts and arriving at joint decisions. Public sector - industry cooperation is good for the public organization, good for business and good for technology transfer. The academic-industrial complex represents a significant change in the organizational structure of the system of agricultural science and technology in the developing world (Trigo 1988).

AICCCIPs - processing industry collaboration

With emphasis on value added products, and the orientation being given to crops in the breeding process towards end-product use, the involvement of the user industry becomes essential. Either in the NRC or in an appropriate faculty in the university, a small unit for process oriented research and collaboration needs to be established.

Personal selection, equipment, funding procedures and research environment

Adequate attention to choice of right personnel, field, lab and computer facilities, flexible funding procedures, commitment, and positive altitudes of scientists, administrators and supporting staff are all essential elements for promoting a spirit of industry, exploration and accomplishment.

Management of change

In a criticism of the USDA led agricultural establishment, Winrock (1982) observed the following : ineffective scientific leadership; piecemeal approach to basic agricultural research; failing to fund most important areas of science;' losing its role on the cutting edge of agricultural science; distributing federal funds on the basis of geopolitics etc. The suggestions including pruning deadwood from the system and where necessary even by closing down facilities. They bought out the

drawbacks in the block grant funding. They also suggested structural changes. Our present situation is worse and changes are warranted in function, structure and procedures. Some of the elements of change, both technological and structural, were discussed in the preceeding pages.

Technological change involves invention, assessment and transfer of technology. It is essentially a process of knowledge change, a cognitive process involving changes in the structure and content essentially a qualitative phenomenon, a simplified means of transforming complex knowledge created by scientists and technologists into a simplified form that farmers could absorb to produce desired outputs (Parayil 1991).

When people are faced with change, the possible outcome are - confusion, concern, anger, initial acceptance, anxiety, indecisiveness, distrust, fear possible loss of productivity and even paralysis (Nightingale 1990). A statement codifying the primary strategic goal of the organisation, its vision for the future and a charter that defines future in terms of strategies, values in terms of organization and the people who work there, is essential. The vision should strike a balance between direction and flexibility. In the words of Nightingale (1990). "the organization should be made the basis of an ongoing proactive programme of execution, establish direction, set strategy, provide a clear focus for effective decision making and create a basis for the kinds of behaviour at all levels of the organization. A mission that is properly developed and properly implemented can create the context in which the need to change is seen as adding to stability to the enterprise rather than creating instability". Apart from the statement of mission, "the involvement of people at every level creates the kind of environment in which change takes place. The challenge is to get people in the process and make them creative and satisfied participants in change. The ability to instill in people a valued purpose is a critical and rare talent".

Research and coordination of research are not separable. The experience in this area in a vast country of the magnitude of India has been rewarding and satisfying. An overview of the developments in the country's research system and current altitudes cause concern. The future is looked at as an opportunity, not destiny. Every thing is changing and interacting. The All India Coordinated Programmes are by far the best agents for synergy. The foregoing account is an attempt to provide a conceptual frame work for future. It is necessay that every individual project be looked and analysed to arrive at specifics for each of the projects to effectively serve the cause of agriculture. That shall be the challenge.

REFERENCES

Anderson WT (1990) Food without farms. The Biotech Revolution in Agriculture. The Futurist, **24**(1): 16-21

Clark N (1987) Similarities and difference between scientific and Technological paradigms. Futures, 19(1) : 26-42

Doyle J (1985) Altered l larvest, Viking Penguin, New York

Nightingale GJ (1990) Effective organizations. Futures Res Qly, 6(3) : 13-19

Parayil G (1991) Technological knowledge and technological change. Technology in society, **13** : 289-304

Piementel D, Culliney TW, Buttler IW, Reinemann DJ, Beckman KB (1989) Low sustainable agriculture using ecolgical management practises. Agriculture, Ecosystems and Environment, **27**:3-24

Rao NGP (1989) Perspectives in agricultural research and develpment in India: Some issues for analysis and data base. Dr. Rajendra Prasad Memorial Lecture, 42nd Annu Conf Indian Soc Agric Stat, Jorhat, pp 1-18

Rao NGP (1991) Advancing dry land Agriculture: Plant breeding accomplishments and perspective. 2nd B.P.Pal Memorial Lecture, Feb 12, 1991 (in press).

Trigo EJ (1988) Private sector participation in agricultural research and development. In : Changing Dynamics of Global Agriculture. Proc Sem, Res Policy Implications for National Agricultural Research Systems, pp 285-308

Vanwyk RJ (1987) Technological analysis : An imperative for modern management (Book review). Futures, 19 :347-349

Walker YS, Ryan JG (1990) Village household economies in India's semiarid tropics. The Johns Hopins University press, Maryland, USA

Weil RR (1990) Defining and using the concept of sustainable agriculture. J Agron Educ 19:126-130

Table 1. Progress of production of some agricultural commodities in India (mt)

Crop/Commodity	Five year peiods				
	1950-51	1960-61	1970-71	1980-81	1988-89
Foodgrains	50.82	82.02	108.42	129.59	170.25
Rice	20.58	34.58	42.22	53.63	70.67
Wheat	6.46	11.00	23.83	36.31	53.99
Coarse cereals	15.38	23.74	30.55	29.02	31.89
Grains legumes	8.41	12.70	11.82	10.93	13.70
Oilseeds	5.16	6.98	9.63	9.37	17.89
Cotton (m bales)	3.04	5.60	4.76	7.01	8.69
Jute (m bales)	3.31	5.26	6.19	8.16	7.7
Sugarcane	57.05	110.00	126.37	154.25	204.63
Potato	1.66	2.72	4.81	9.67	14.89
Tobacco	0.26	0.31	0.36	0.48	0.49
Coconut (m nuts)	35.82	46.39	60.75	57.20	81.61

Table 2. All India compound growth rates of crops in the green revolution era (1967-68 to 1988-89)

Crop/Commodity	Area	Production	Yield
Rice	0.56	2.60	2.06
Wheat	2.02	5.27	3.17
Coarse Cereals	– 0.97	0.42	1.34
Sorghum (Jowar)	– 0.64	1.23	1.88
Pearl millet (Bajra)	– 0.86	– 0.04	0.81
Maize	– 0.10	0.89	1.00
Finger millet (Ragi)	– 0.02	1.52	1.55
Small millets	– 2.60	– 2.30	0.31
Total Pulses	0.30	0.74	0.51
Chickpea (Gram)	– 0.68	– 0.45	0.22
Pigeon pea (Arhar)	1.44	1.96	0.51
Oilseeds			
Groundnut	0.08	1.23	1.14
Rape & Mustard	1.50	4.01	2.48
Cotton	– 0.35	1.83	2.18

Models for Plant Variety Registration and Grant of Plant Breeders Rights in the European Community and the Developed World

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This is potentially a very wide ranging topic which requires a detailed knowledge of plant variety testing systems and their interaction with Government policies not only in relation to agriculture and related industries but also to fiscal and economic policy. I am unable to deal with the subject in such an ambitious way. Instead I propose to consider developments in the United Kingdom from 1945 to the present day and draw on some information from other countries. I have divided the period into three; 1945 to 1964, 1946 to 1972 and 1972 to 1992 and hope to provide examples of plant variety testing models and their evolution in response to changing circumstances. I think it is important to emphasise the evolutionary nature of variety testing systems. The word 'model' perhaps implies something which is static but experience in the United Kingdom suggests that systems are only static for short periods of time if they are static at all.

The period 1945 to 1964

In the United Kingdom as in many other European Countries this was a period of re-establishment of agriculture and other industries following the ravages of the second World War. It was a period of Government investment in agricultural research and development to improve the productivity and ensure national food supplies. The availability and use of improved crop varieties was seen as one of the means of improving agricultural productivity. At this time in the United Kingdom there were no official systems of registering varieties, no plant breeders rights and no official seed certification schemes. The forerunners of certification schemes existed as part of the wartime efforts to ensure an adequate supply of seed and to encourage seed production. Most of the plant breeding effort was State funded with the research effort biased towards the solution of fundamental scientific problems rather than ensuring a steady flow of varieties for use by the farmer. There was no control over the use of varieties so that as soon as a new variety was introduced it could be taken up by anyone and marketed. For the more important crops, notably cereals (wheat, barley, oats), the National Institute of Agricultural Botany (NIAB) carried out variety trials to produce recommended lists of varieties for farmers. The NIAB variety trials were largely State funded, although NIAB is an independent organisation. The morphological characters of varieties on the NIAB recommended lists were described and used in a NIAB controlled voluntary seed certification scheme which was introduced in 1947. This was a simple scheme which 'approved' seed crops in the field. It was not until 1955 that the 'certified' category of seed was introduced.

In summary, there were State funded plant breeding stations, very few private plant breeders, no official registration or testing of varieties. Variety trials and embryonic seed certification schemes were run by NIAB. The variety trials were supported by the state but fees were paid to cover at least part of the cost of the seed certification schemes.

It is interesting to compare the situation in the United Kingdom with that in some other European Countries where plant variety testing was much more organised.

In France most of the plant breeding work was done by private firms and individuals with the more fundamental research being carried out by State funded research stations which also provided valuable material to private breeders for further selection. There was no statutory scheme for plant breeders rights, but for some important crops voluntary arrangements were made between breeders, seed producers and farmers to protect new varieties. The arrangements were supported by the Government and depended on seed control laws and the French trade mark legislation. The framework of protection was provided by the following:

- a breeder could trade mark the variety name, which enabled him to licence others who wished to use the trade mark when selling the variety;
- seed of a variety could not be sold until it had been officially tested and registered under its name in the official catalogue of varieties. To be registered a variety had to be distinct, uniform, stable and of cultural value in France.

Germany had statutory plant breeders rights and seed control laws which effectively required registration of varieties and a restriction on the sale of varieties in Germany which had been shown to have value for agricultural production in official trials. Germany had a thriving private plant breeding industry.

In the Netherlands plant breeders rights legislation was introduced in 1941 and most plant breeding was in private hands with Government research stations providing supporting fundamental research and material for further selection. Variety performance was not required for plant breeders rights but only varieties which in official trials showed a clear improvement over existing varieties could be officially listed and sold.

At this time the system in the United Kingdom provided little incentive to the development of a viable plant breeding industry and the breeding of varieties specifically for United Kingdom conditions. Our neighbours in France, Germany and the Netherlands had thriving plant breeding industries and provided a degree of protection and reward to private breeders. The marketing of any variety which had not been effectively evaluated in official trials was prevented and this had the effect of putting pressure on breeders to seek improved variety performance.

The weakness of the United Kingdom plant breeding industry and inadequacy of seed quality control measures were recognized as placing United Kingdom agriculture at a disadvantage compared with other European countries. In 1949 it was estimated that 61 percent of cereal seed in the United Kingdom was of varieties from foreign breeders, United Kingdom State bred varieties accounted for 35 percent

but 28 percent was in one variety), and 4 percent from private breeders. The Government commissioned three reports during this period, Report of the Committee on the Qualitative Control of Seeds (1950), Report of the Committee on Transactions in Seeds (1957), and Plant Breeders Rights, Report of the Committee on Transactions in Seeds (1960), on which to base future policy.

The recommendations in these reports led to the strengthening of United Kingdom seeds legislation in order to encourage private plant breeding and improve seed quality. There were also two developments on the International stage which had an important influence. These were the introduction of the first OECD schemes for the certification of seed moving in international trade in 1959 and the signing of the first UPOV Convention for the protection of new varieties of plants in 1961.

The period 1964 to 1972

The most important change during this period arose as a result of the report on Plant Breeders Rights referred to above. The Plant Varieties and Seeds Act 1964 introduced three important provisions in the context of this paper; the protection of varieties through the grant of a plant breeders right, the establishment of an Index of names of plant varieties, and the introduction of performance trials and reports for new varieties.

The United Kingdom was one of the first countries to sign the UPOV Convention for the protection of plant varieties. The Convention required that for a variety to be given protection it should be novel, distinct, uniform and stable. There was no requirement for the agricultural value for cultivation or use to be established as required in some National Schemes already in existence at that time, e.g. Germany. The provisions of the UPOV Convention were implemented in the 1964 Act and the other signatories to the Convention, mainly west European countries, also introduced National legislation to implement its provisions. The result of this was to establish an Internationally agreed system of plant variety protection implemented by National legislation. Plant breeders rights thus became separated from National requirements for the registration of varieties for the control of certification and marketing by removing improved variety performance as a requirement for variety protection.

In the United Kingdom and other European countries a variety does not have to be protected as a requirement for marketing. It is the breeders decision to decide whether or not he wishes to benefit from the protection which the grant of a right covers. The creation of an Index of names of plant varieties went some way towards the requirement for an official catalogue of varieties, referred to earlier, as a pre-requisite to selling varieties in France, Germany and the Netherlands. In these countries registration could be refused if the variety did not have value for cultivation and use, but the United Kingdom Index did not go this far. In the United Kingdom the requirement was that if a variety was sold under a variety name then that variety name should be on the Index. The object of the Index was to establish the existence of a variety by registering its name, with a description covering its most important characteristics. A sample of seed of each variety on the Index was required by the Authorities and formed reference collections of varieties. Provision was also made for the examination of varieties added

to the Index to ensure distinction from other varieties, removal of homonyms and synonyms to provide a description which could also be used in seed quality control and certification. For the most important crops provision was also made for statutory performance trials to be conducted but a pre-determined level of performance was not a condition of addition to the Index. A report of the trials however, was publicly available so that farmers and others could make their own decisions about the likely value of a variety. Non-statutory performance trials, notably Recommended List trials carried out by the NIAB, provided extensive, reliable and independent trials on which varietal choice could be made. The implementation of the Index provisions of the 1964 Act were just beginning to show an effect when the United Kingdom joined the European Community in 1972. Nevertheless private plant breeding had begun to expand and far more sophisticated seed certification and seed quality control systems had been introduced as a result of the much stricter control of varietal names.

In summary, the object in the United Kingdom was to encourage private plant breeders, and to improve the varietal quality of seed available to the farmer at a reasonable cost. Official examinations required under the 1964 Act were heavily subsidised by the State but the cost of seed certification, which was voluntary, was largely covered by the payment of fees. The Index ensured that varieties were distinct and uniquely named but cultural value was not a condition for acceptance. The role of officials and variety testing organisations was limited in general to providing information and guidance, and to encouraging breeders and others to fully test their varieties before putting them on the market. It was recognised however that as the efforts of breeders in the United Kingdom and freer trade between countries increased, the non-restrictive nature of the Index might have to be reconsidered.

The period 1972 to 1992

The United Kingdom joined the European Community (EC) in 1972. The 1972 European Communities Act which amended the 1964 Plant Varieties and Seeds Act, implemented the EC Directives on the marketing of seeds and National Listing of varieties of agricultural crops and vegetable crops. The marketing directives deal with seed certification and make seed certification compulsory. The Common Catalogue directive makes the registration of varieties in National Lists compulsory. The National Lists from each Member State are combined to form EC Common Catalogues of varieties. Membership of the EC had no immediate effect on the Plant Breeders Rights legislation as this remained a National rather than an EC provision. There is, however, an EC Plant Breeders Rights regulation in preparation which is likely to be introduced in 1993.

The objects of the EC Directives can be summarised as follows:

- to encourage plant breeding and the improvement of varieties for cultivation and use;
- to safeguard the quality of seed supplied to the consumer; and
- to allow the free marketing of seed throughout the EC Members States.

The requirements for placing a variety on a National List reflect the systems referred to earlier which operated in France, Germany and the Netherlands in the 1950's. All the tests and trials have to be carried out

by officials. If a variety is to be admitted to a National List it must be distinct, uniform and stable and show an improvement in value for cultivation and use over other varieties in the country of admission. At present the varieties of most agricultural crops have to be on a National List for two years before transfer to the Common Catalogue. This rule allows varieties to become well established in the country of admission and encourages breeders to develop their varieties for particular countries or climatic areas. Although marketing is not normally restricted after addition to the Common Catalogue it is generally the case that the most successful varieties in a particular country are first admitted on the National List of that country. It is generally recognised that the statutory trials for admission to the National List provide the data on which the best varieties admitted can be chosen for more extensive and detailed trials for advisory purposes. These additional trials are not compulsory.

In the United Kingdom during the early 1970's it was still Government policy to encourage plant breeding and greater crop productivity. During this time tests and trials for National Listing and for Plant Breeders Rights were heavily subsidised by the State. The tests for distinctness, uniformity and stability (DUS) were carried out at two or three sites in order to account for any environmental effects on the expression of morphological characters. Performance trials were conducted on a large number of sites with a large number of replicates. By the end of the 1970's the economic climate had changed and a large number of varieties were being entered for National Listing. The cost to the State was becoming too high and fees were introduced at least to cover part of the cost of the statutory procedures. Efforts were made to reduce costs by reducing numbers of sites and replication within trials. The problems associated with the costs of statutory tests and trials for National Listing, plant breeders rights and seed certification become so serious that in 1988 the Government commissioned a report on the operation of statutory plant variety testing and certification systems in the UK, the inter-relationship between these systems and the recommended list trials undertaken by NIAB largely with funds provided by the Government.

As a result of the recommendations made in this report the following changes were made:

- DUS tests were reduced to one site for any particular crop although three test centres remained;
- For less important crops DUS tests were arranged with other EC Member States under bilateral agreements;
- Breeders were forced to pay 100 percent of the cost of DUS tests;
- Statutory trials for value for cultivation and use (VCU) were shared between the Authorities and other organisations contracted to the British Society of Plant Breeders operating under strict licence conditions imposed by the Testing Authority. Up to 50 percent of VCU trials for a particular crop could be operated under licence at direct cost to the breeders.
- Government funding for the non-statutory Recommended List trials operated by NIAB was gradually withdrawn leaving the plant breeding, seed and farming industries to pay for these trials.

The effect of these changes has been to transfer a significant part of the cost from the Government to plant breeders and the farming industry. Within the EC over-production in agriculture and protection of the environment are the most pressing problems and it is now less important to stimulate plant breeding and increase crop production.

In summary, the period 1972 to 1992 brought an immediate change from mainly voluntary systems of control to statutory systems imposed by EC Directives. The early part of the period continued to stimulate plant breeding with State supported technically complex and extensive trials, but as economic, other market forces and environmental issues began to increase in importance the systems were simplified and much of the cost transferred from the State to the private sector.

Similar changes are taking place in other European Countries.

Conclusions

In this brief discussion of the developments in plant variety testing in the United Kingdom, I have tried to illustrate how the systems for variety testing are required to respond to the needs of agriculture, economic problems and changes in policy. Variety testing is a costly operation and if the most cost effective systems are to be introduced, the resources available at the starting point, the objectives of the system, the cost of maintaining the system and the likely line of development in the future need to be defined as clearly as possible. It is also the case that having set up a system it will require development and modification and this is almost a continuous process.

In the United Kingdom we are now debating how our variety testing systems will be affected by the introduction of EC Plant Breeders Rights, the freer marketing of varieties in EC Member States, rationalisation of the plant breeding industry, the influx of varieties from Eastern Europe and development of a European Free Trade Area with the Scandinavian Countries, Switzerland and Austria, and the impact of biotechnology on plant breeding.