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MULTILOCATIONAL TESTING IN THE ICRISAT CROP IMPROVEMENT PROGRAMS

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The crop improvement programs -- pearl millet, sorghum, pigeonpea, chickpea and groundnut -- of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) use multilocational testing as an integral part of their endeavors to assist national program scientists identify and develop new high and stable yielding, stress resistant crop cultivars and to encourage the development of an intercommunicating, cooperating, international network of scientists. Three basic categories of locations have been included as components of the ICRISAT multilocational testing system: (i) center-operated locations in India; (ii) center cooperative program locations in other countries, mainly in Africa; (iii) national program locations. In order that national program scientists are not overloaded with nonadapted material, initial screening is done at the center-operated Indian locations and at the center cooperative program main stations.

After only a few years of operation the multilocational testing programs can be seen to be contributing to the improvement of the ICRISAT five crops in the semi-arid tropics. Sources of wide adaptibility, and location nonspecific stress resistances have been identified, and the development of communicating cooperating networks is well under way. Many early problems concerning suitability of material, timely despatch of trials, return of usable results etc. have been solved or minimized, and it is realized that the solutions to many of these problems lie largely

with the center scientists. It is most important that the scientists learn of the capabilities, interests, and resources of the cooperators; the specific environmental characteristics of the locations; and that they match the nature and size of trials to these parameters. Details of multilocational trials are presented, problems encountered are discussed, and general questions of philosophy and policy are raised.

As most of the crop IARCs are involved with multilocational testing, some of them for as much as 15 to 20 years, the opportunity to discuss programs, problems, achievements, failures on an inter-center basis is welcomed.

INTRODUCTION

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) was established near Hyderabad, India in 1972 with the basic mandate to develop technology that will enable the small farmer of limited means in the rain-fed, seasonally-dry, semi-arid tropics (SAT) to produce sustained higher food crop yields. A vital part of the new technology has to be novel, highly productive crop varieties. To meet this responsibility ICRISAT has established programs for the improvement of five crops -- sorghum, pearl millet, chickpea, pigeonpea and groundnut -- in which teams of scientists strive to identify and utilize yield increasing and stabilizing traits. Multilocational testing has been developed as an integral part of the crop improvement efforts. In this paper we have attempted to summarize the philosophy, operations, problems and achievements of the ICRISAT crop multilocational testing activities, which aim at the targetted area of the World's semi-arid tropics.

WHY MULTILOCATIONAL TESTING

The new crop genotypes produced by ICRISAT should contribute to national programs in the semi-arid tropics around the world. They must be capable of providing stable high yields which means that they must possess resistance to fluctuating stress factors such as variable rainfall, varying fertility levels, insect pests, pathogens, parasitic weeds, and various combinations of them. Thus the basic aim of the crop improvement

teams is to identify and develop genotypes that are highly productive, widely adapted, with stable pest and disease resistance. Multilocational testing provides the means whereby this can be achieved.

Multilocational Testing & Breeding

Multilocational yield trials are an accepted procedure for testing the adaptability of elite finished products, i.e. varieties at an advanced stage ready to go to the farmer. Clearly the breeding procedures used to develop the material up to this stage should include evaluations of adaptability through the exposure of early generations to different environments, thus determining their potential and limitations. This is the basic rationale for the multilocational breeding aspect of the multilocational testing programs.

Multilocational Testing & Disease & Pest resistances

Multilocational testing is needed in the initial phase of primary screening for resistance sources, for not all important diseases and pests of a crop will occur at one location. However, the most important aspect of multilocational screening for pest and disease resistance is related to the need for identification of stable and durable resistances. The large scale adoption of a resistant genotype exerts a high selection pressure on the pest or pathogen for a new biotype or race to overcome that resistance. Methods are needed to identify stable resistances. We believe the best method is to expose resistance sources to many and varied populations of the pests and pathogens under a wide range of

environmental conditions. Test locations in the centers of origin and centers of diversity of the crops are most important, for the host and pathogen have co-evolved there over long periods of time and thus the greatest variability in the pest or pathogen is likely to be found there. If sources of resistance can be found which are in the short term stable across many populations of pests or pathogens they are likely to be more stable over time (durable) to any one population than resistance which already is known to be population specific. Thus we use multilocational testing in an attempt to identify stable and consequently more durable resistance. In the process information is obtained on pest and pathogen variability and host components are identified that may be utilized to create more stable resistance e.g. in the production of multilines.

Multilocational Testing and National Programs

Apart from the contribution of multilocational testing to the identification of widely adapted productive crop varieties, and to the rapid dissemination of valuable genotypes, there is another important contribution in the encouragement and catalysis of the activities of national program scientists. The development of inter-communicating cooperating international networks of scientists is an important aspect of the multilocational testing programs.

Summary of Multilocational Testing Objectives

From the above we can summarize the objectives of multilocational testing thus:

- to identify factors affecting the adaptability, stability and acceptability of crop varieties
- to identify the potentials and limitations of new genotypes and thus enable the development of new cultivars with broad adaptabilities
- to identify sources of stable pest and disease resistances
- to characterize variability in pest and pathogen populations
- to distribute valuable genotypes to scientists in national programs
- to promote intercommunicating cooperating networks of scientists.

ORGANIZATION OF MULTILOCATIONAL TESTING

There is no central control of multilocational testing at ICRISAT. Multilocational test nurseries have been developed within each crop at subprogram level -- pathology, entomology, breeding -- but there is a trend toward closer collaboration among the subprograms in the formation and operation of these nurseries. There are no staffing plans in the near future for the establishment of international testing units to conduct all the international testing activities within a crop. The advantages and disadvantages of such a single coordinating unit need to be discussed.

LOCATIONS, COOPERATORS, TEST MATERIALS AND THEIR INTERRELATIONSHIPS

Locations and Cooperators

The locations and cooperators in the ICRISAT multilocational testing system can be classified thus:

1. Center controlled sites operated by center staff. ICRISAT, through a cooperative agreement with the Indian Council of Agricultural Research, has established four subcenter sites (Table 1) within 1 or 2 days traveling distance from the center, which have specific required environmental, pest or pathogen characteristics.
2. Center cooperative program sites operated by ICRISAT cooperative program staff. These have been developed in several African countries in response to government requests to assist national programs, and at two other IARC's (Table 2).
3. National program (NP) sites operated by NP staff. These are the research stations in national agricultural research programs. They can be usefully further classified into: (i) NPs with well developed agricultural programs and organizations; (ii) NPs with less developed programs and organizations.

Test materials

There are many different types of materials entering multilocational trial including:

1. parent lines and base populations
2. early generation segregating populations and progenies
3. advanced breeding lines
4. elite varieties and hybrids
5. pest, disease, parasitic weed, drought resistance sources
6. biotype and race characterizing differentials
7. N_2 fixing host genotypes
8. strains of N_2 fixing microorganisms
9. pesticides

Interrelationships Among Locations, Cooperators & Test Materials

If the multilocational testing programs are to meet the objectives listed above there has to be a careful matching of locations, cooperators, and test materials. The specific environmental characteristics of the locations must be clearly known along with the duties, abilities, interest, and resources of the cooperators. If the matching is done correctly then there should be no question of "overloading the cooperator" or "supplying non-contributing material". The general route (Fig 1) for materials is (or should be):

1. testing at ICRISAT center
2. testing at ICRISAT operated subcenters
3. testing at cooperative program centers
4. testing in national programs

There will be exceptions to this routing -- for example if a major pest, pathogen, or environmental factor such as high altitude does not occur

at the center, but there should always be good justification for them based on compatibility of material with location characteristics and cooperators requirements and capabilities.

From the above it is obviously important that the researcher at the center should be thoroughly familiar with the locations and researchers in the center's area of operation and this is best achieved by visits to the locations and from discussions with the researchers.

MULTILOCATIONAL TRIALS/NURSERIES COORDINATED BY THE ICRISAT CROP IMPROVEMENT PROGRAMS

Pearl Millet

In the pearl millet improvement program a well-coordinated multilocational testing system has been developed for breeding materials, disease resistance sources and for advanced yield trials. The center-operated locations in India and center cooperative program locations in Africa are used for testing large numbers of breeding materials and disease resistance sources. A few breeders in national programs have been supplied with some of the breeding nurseries in response to requests from them, and pathologists in national prog _ , particularly in India, participate in the International Pearl Millet Disease Resistance Testing Program. The advanced yield trial, IPMAT, operated since 1974, contains entries from several cooperators as well as center products and is a well supported trial. The 1979 trials are listed in Table 3.

Achievements of the program in the short time of its existence include the development of downy mildew resistant hybrids and varieties which are performing well in the Indian national millet advanced yield trials, the identification of location non-specific resistances to the major disease problems -- downy mildew, smut and rust -- and the location of lines to be used in developing acceptable levels of ergot resistance.

In African countries we do not expect to make direct contributions of finished products, as that is the job of the cooperative program/national program staff, but we will continue to provide them with a range of variable breeding material from our advancing and improving populations and the pedigree cross programs, and they in their turn will be contributing toward the improvement and advancement of this material.

Sorghum

The sorghum program is developing an integrated multilocational testing program utilizing the Indian center-operated locations and the expanding cooperative program locations in Africa. The range of breeding material and stress resistance nurseries is similar to that of pearl millet. The 1979 trial details are summarized in Table 4.

Entries from the Sorghum Elite Progeny Observation Nursery, which consists of material selected for low susceptibility to grain molds, elite agronomic type, high yield potential, and good grain quality, have been utilized in national program trials and breeding programs in several African countries. In the disease nurseries consistently low susceptible

lines to grain molds have been identified, one of which has been moved directly into on-farm trials in Mali, and one line in the International Sorghum Downy Mildew Nursery (QL-3) has been immune to SDM in three years of tests at all test locations in USA, Venezuela, Botswana and India.

Chickpea

The chickpea international testing program was initiated in 1975-76 and since that time the trials have been conducted at a total of 67 locations in 28 countries. The 1979 nurseries are listed in Table 5.

Any person or a national program may nominate lines for entry into various international trials and nurseries for multilocational evaluation and wide dissemination of superior genetic material.

The program has allowed the characterization of chickpea growing environments in some countries and regions. Entries with superior performance at individual locations and over locations and years have been and are being identified. Despite small plot sizes and large numbers of entries, in screening nurseries in chickpea it was observed that ranking did not change substantially over years and thus one year of multilocation testing in these nurseries is sufficient to reject lines with poor performance.

Several entries from ICRISAT chickpea trials and nurseries have out-yielded local checks by substantial margins at various locations indicating the opportunity for breeders to select at individual locations.

Several cooperators have informed us of the usefulness of these nurseries and trials from which they have selected lines and cultivars for advanced trials and for hybridization. Some entries grown in the national programs in India are being tested in the advanced national program trials.

In international cultivar trials complex entry x year and entry x location interactions have been observed. However, a few entries in these tests have consistently shown better performance over years and locations indicating that wide adaptation is not common but does exist.

Several lines have been identified with across location *Fusarium* wilt resistance. Entry differential response has indicated the presence of physiologic races in the pathogen (*F. oxysporum* f. sp. *ciceri*). This is helpful in planning for breeding for wilt resistance. In addition, several root rot resistant lines have been identified and a few *Ascochyta* resistant lines were identified in desi and kabuli types.

Pigeonpea

The multilocational testing program in pigeonpeas initiated in 1974-75 has helped in characterizing environments for maturity groups and identifying genotypes performing well at a number of locations. Scientists in Zambia, Dominican Republic, and Cape Verde have selected cultivars for farmer use.

In the international vegetable type trial, promising lines have been identified in Kenya, Puerto Rico, Panama, and Venezuela. In Trinidad,

promising base populations have been identified for further selection under local conditions. In Australia, photoperiod insensitive material has been identified from a segregating population of Pant A-8.

Promising sterility mosaic resistant source material has been identified in the medium maturity group by ICRISAT pathologists. Three ICRISAT entries were found resistant to wilt across test locations. The 1979 nurseries are listed in Table 6.

Groundnut

The ICRISAT groundnut improvement program is the youngest of our crop programs and is just beginning to embark on its program of multilocational trials. The plans for breeding, stress resistance and yield nurseries appear to be similar to those of the other crop programs. Details of the 1979 nurseries are given in Table 7.

GENERAL PROBLEMS IN MULTILOCATIONAL TESTING

Timely Despatch and Receipt of Seed

Data analyses, seed production, plant quarantine, reliance on mail and airlines, and variable sowing dates in different regions all contribute to the problems of getting the right seed to cooperators at the appropriate time for them to plant, and in the return of and report preparation. Some of these problems such as mail and airfreight delays are pretty much beyond center control (except to try to choose a more reliable route/airline, or to hand carry). At ICRISAT delays in

despatch through quarantine have been minimized by the establishment of a well equipped and staffed export quarantine laboratory at the center. The establishment of an interactive computer system and the development of a well stocked library of programs for data analyses, plot randomization, field book preparation and label printing (Appendix I) has reduced considerably the time required for these operations.

Data Return, Reliability and Timeliness

On of the problems expressed by many of our colleagues is the poor return of data from national program staff. Data may not be received at all, or questionable or unreliable data are returned. The solution to this problem must lie largely with the center. We must remember that we are working in some of the poorest areas in the world, where trained manpower and financial resources for experimentation are limited. As stated in an earlier section of this paper it is important for the center researcher to know the cooperators, their resources, abilities, and requirements, and to match the trials to them accordingly. Clearly produced instructions in field books and non-complicated unambiguous data sheets will also help with this problem. In many of the countries in the ICRISAT sphere French is the *lingua franca*, yet we do not produce the field books or reports for any of our trials in this language. Problems in apparent non-reliability of data are most often due to a lack of required knowledge or training in the particular aspects of the trial. Visits to the cooperators locations and the conduct of training courses and workshops will minimize these problems.

Contributory factors to these problems at national program level which are outside center control include delayed seed release by the plant quarantine authorities, frequent staff movements, and delayed release or non-release of funds for labor, farm operations, fertilizer etc.

Data Analyses and Report Preparation

In order that ICRISAT researchers and cooperators can make good use of the data, reports must be rapidly produced and disseminated. This is also an aspect that encourages cooperators to grow the trials and grow them well. Every effort must be made to meet this coordinating responsibility of multilocational testing.

In addition to the necessary detailed annual report there is an important requirement for a broader analysis -- over several years data -- so that important relationships between climate, pests, diseases, and types of material adapted to particular regions can be identified. They will also help answer questions on plot size and replication requirements. There is still a great deal of debate on just how results from multilocational yield tests should be analyzed. The centers, with massive amounts of data over several years, need to link up with biometricians and quantitative genetecists at universities in order to fully utilize the data available and to contribute to the development of the science of biometrical analyses of multilocational trial data. Standardized methodology and the inclusion of the same standard checks over time are needed to

facilitate such analyses. We would like to know if and how such broader analyses are being made in any of the programs of other IARCs.

Inclusion of non-ICRISAT Trial Entries

In the more advanced yield trials and in the disease and pest resistance nurseries we encourage inclusion of entries contributed by national program scientists. This works well for contributions from Indian scientists, but the Indian plant quarantine import regulations make difficult the inclusion of entries from other countries, generally delaying seed availability for the trial by one year. This problem has, for example, prevented Texas A & M from participating fully in the sorghum disease nurseries. In this instance a system will have to be developed whereby candidate entries from Texas A & M are sent to a few key center cooperative program locations at the same time as they begin their slow journey through the Indian quarantine procedures. By the time we have sufficient seed to include in the multilocational trials we will have some results which will indicate whether or not it is worthwhile including them.

There is a general principle that arises from this discussion concerning the advisability of the routing of materials from U.S. university programs and other international organisations such as FAO through the IARCs and their subcenters. This would help reduce the problem of swamping national program researchers with material which may be quite unadapted. But is it desirable to attempt centralised coordinated control of multilocational testing by international bodies? Do national program researchers want such a system?

Plant Breeders' Rights and Supply to Commercial Seed Companies

ICRISAT has a policy of not releasing named finished products and thus is not in the business of claiming "plant breeders' rights".

As ICRISAT is a world center to improve the genetic potential for grain yield and nutritional quality of sorghum, pearl millet, pigeonpea, chickpea and groundnut, and as it is a repository of world germplasm in these crops, scientists all over the world look to ICRISAT for exchange of germplasm and elite seed material of these crops. The Institute, being a research organization, generally follows a philosophy that it will make available the seed, promising breeding material at segregating stage, and germplasm freely on request to research organizations, whether governmental or private.

A question has arisen whether in developing countries it is advisable to release the material at the segregating stage of unapproved seed or at prerelease stage to private commercial seed companies. One view is that such elite material should not go to private companies which could exploit the poor farmers; this would mean a restriction in release of such elite material. But there is also the danger that in the hands of a bureaucratic organization the promising seed material which is capable of generating excellent hybrids and varieties suited to different conditions may not be exploited properly or suffer from undue delays. In developing countries such a danger is real. Absence of competition also leads to inefficiency. In view of these facts we

believe that we should not hold back any promising breeding material from any research worker who expresses interest in it. Thus, private commercial seed organizations who are engaged in developing their own hybrids should not be denied this opportunity of making use of our promising material. An international institute will appear partial if it denies its benefits to some section or group of people or organizations. On the other hand, it may be blamed for encouraging exploitation of poor farmers by private organizations. We will be interested to learn of the policies of the other crop IARCs on this subject.

Documentation and Quantification of Center Contributions

The IARCs depend upon donations for their continuance, and in a world with considerable competition for donors' money -- both within the IARC system and among broader categories of activities -- donors require evidence that their money is being well used. The "green revolution" successes with dwarf wheats and rices was sufficient to generate enough confidence in the IARC philosophy to establish IARCs for other crops. These new IARCs, in their turn, must not only succeed in their endeavors, but must be seen to succeed. This requires documentation and quantification of the contributions by the IARCs to national programs and to the farmers they serve. This is more difficult when the emphasis is on providing national programs with source and breeding material rather than finished products with center-identifiable names. It will be important for ICRISAT to learn from the experiences of some of the older institutes how to cope with this problem.

SUMMARY OF CENTER RESPONSIBILITIES IN MULTILOCATIONAL TESTING

The center's main responsibility is to develop and disseminate technology to solve problems of low and unstable agricultural production. The aim of multilocational testing is to identify and develop superior crop genotypes that will contribute in national agricultural programs. In cooperative trials with national programs our responsibilities include the following:

- to guard against distribution of pests or pathogens with seed; national plant quarantine requirements have to be respected. ICRISAT, in collaboration with the Government of India has established a Plant Quarantine Unit to deal with the phytosanitary aspects of multilocational trial seed. These activities are described in a separate document
- to match cooperators and test materials so that the material is likely to contribute to and does not overload the cooperators program
- to send trials sufficiently in advance for planting by the cooperators at the appropriate time
- to provide sufficient information in the right form and language for the proper conduct of the trial, including adequate information on the methods of assessment and data recording
- to refrain from requesting excessive data collection
- to provide encouragement and assistance where needed by

visits by center staff and through field days, training programs, and workshops

- to provide rapid analysis of data and preparation and distribution of reports so that the cooperators can make full use of the data
- to maintain seed of useful lines and distribute them on request to any and all requestors
- to provide opportunity for cooperators to contribute materials to the trials and to participate in discussions on trial format, management, etc. The establishment of regular workshops well serves this purpose.

SUMMARY OF QUESTIONS AND DISCUSSION POINTS

As we reread our paper we see many questions concerning multilocational testing which we believe should be raised and discussed. We have given our ideas for the solution to some of the problems but we will benefit greatly from learning how these questions have been answered and how these problems have been handled in other IARC programs. Some of the most important questions are:

1. Is there any dissension to the rationale that multilocational testing provides the means of identification of wide adaptability, stable stress resistances, and is one of the major activities required of the crop IARCs in their endeavors to assist national agricultural programs?

2. Is it fully accepted that multilocational testing provides the means to identify more durable disease resistance, or at least to identify the genetic components that can be used to build durable resistance?

3. Is there a real danger of swamping national program cooperators with too many trials? If so, what are the solutions?

4. Should there be a central control of all multilocational trials within a crop -- at center level? -- at an international level?

5. What are the advantages or disadvantages of standardized agronomical practices for the conduct of multilocational trials?

6. How do we optimise entry numbers and plot size to obtain required accuracy and yet not overload cooperators?

7. How do we solve the problems of:-

   i. timely despatch and receipt of seed which include mail and freight delays and plant quarantine delays?

   ii. trials not being conducted well, data not taken correctly and data not returned in good time or good order?

   iii. rapid analysis of data and preparation and dissemination of the reports?

8. Is there a need for a broad analysis of multilocational testing data -- across season, even across crops -- in order to extract valuable information on (i) the value of such testing, (ii) the relationships between environmental factors, types of materials, pest and disease attack, etc.?

9. How do we encourage the participation of national program scientists? How valuable are monitoring tours, newsletters, workshops in this area?

10. How do we learn about and document the utilization of the products from our trials?

11. Should the centers name and release finished products?

12. Should there be any distinction between private commercial companies and government research organizations in the free supply of germplasm early generation and advanced breeding materials?

13. Should the centers get involved in production and exchange of bulk seed for national programs or commercial purposes?

There are undoubtedly other important questions which we have omitted, but which we hope will be raised by other participants or come up in the discussion.

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Table 1. ICRISAT Center-operated research sites[a] in India

Name	Latitude (N)	Altitude (M)	MAR[b]	Crops grown	Area (ha)	Special features
Hissar	29° 10'	221	446	Pearl Millet	18	smut, long days
				Pigeonpea	6	low rainfall, early variety selections
				Chickpea	18	major breeding center
				Sorghum	4	shoot fly, long days
Gwalior	26° 14'	207	903	Pigeonpea	6	long duration selection
				Chickpea	1	-
Dharwar	15° 27'	727	766	Sorghum	7	SDM, rust, charcoal rot
Bhavani-sagar	11° 30'	278	685	Pearl Millet	6	rust, short days
				Sorghum	7	shorter days, longer duration rainfall
				Pigeonpea	0.2	hybrid seed production

a/ In addition to Center HQ at Patancheru near Hyderabad 17° 27' N, 545 M altitude, MAR 800

b/ Mean annual rainfall (mm)

Table 2. Locations where ICRISAT Cooperative Program staff are centered[a/] and present staff (August 1979)

Station	Country	Latitute	Altitude (M)	MAR[b/]	Crop(s)	Staffing[c/]
Bambey	Senegal	14° 42'N	20	632	Pearl Millet	breeder
						entomologist
Sotuba	Mali	11° 12'N	332	927	Pearl Millet	breeder
					Sorghum	agronomist
Kamboinse	Upper Volta	12° 22'N	308	852	Pearl Millet	breeder (3)
					Sorghum	pathologist
						entomologist
						agronomist (2)
						economist
						field trials officer
Maradi	Niger	13° 28'N	369	622	Pearl Millet	breeder
Samaru	Nigeria	11° 11'N	687	1095	Pearl Millet	breeder (2)
					Sorghum	pathologist
Ilonga	Tanzania	6° 50'S	594	1011	Sorghum	breeder
					Pearl Millet	
Wad Medani	Sudan	14° 23'N	405	381	Sorghum	breeder (2)
					Pearl Millet	
Aleppo	Syria	36° 11'N	350	350	Chickpea	breeder
El Batan	Mexico	19° 31'N	2249	-	Sorghum	breeder

[a/] These are the cooperative program "base" stations. Other sites within the countries indicated are also used for trials.

[b/] Mean annual rainfall (mm)

[c/] Breeders are generally confined to a single crop whereas the other scientists work with more than one crop.

Table 3. ICRISAT coordinated pearl millet multilocational trials in 1979

Coordinators	Acronym	Description	Entries	Locations IC[a/]	Locations NP[b/]
Breeders	BPPT	Best Population progenies FSs & SIs	64	6	0
	EVT	Experimental varieties	25	8	3
	PMHT	Elite hybrids	25	7	1
	PMST	Elite synthetics	25	7	0
	ELVT	Hybrids, EVTs and synthetics	32	9	1
	UPN	F_4 & F_5 lines	70	10	3
	IPMAT	Elite hybrids & varieties from ICRISAT and national programs	21	12	29
	IPMSUN	Possible striga resistance sources	32	6	2
Pathologists	Pre-IPMDMR	DM resistant lines from the Center	150	3	1
	IPMDMN	DM resistant lines from the Pre-IPMDMN	45	6	12
	IPMDRT	DM race differentials	25	6	1
	ITFCPMDM	Fungicide seed dressing trial	1	5	8
	IPMRN	Rust resistant lines	45	1	11
	IPMEN	Ergot low susceptibles	28	3	14
	IPMSN	Smut resistant lines	38	5	1

a/ ICRISAT Center-operated locations and ICRISAT cooperative program locations

b/ National program locations

Table 4. ICRISAT coordinated sorghum multilocational trials in 1979

Coordinators	Acronym	Description	Entries	Locations IC[a/]	Locations NP[b/]
Breeders	ISPPT-3	S2 population progenies (RSR)	200	5	1
	ISPPT-4	S2 population progenies (RSB)	200	5	1
	ISPYT-1	S5-10 advanced varieties - early	30	14	24
	ISPYT-2	S5-10 advanced varieties - normal	60	14	24
	SEPON	Elite good grain quality lines	60	9	21
	ISRN	*Striga* resistant lines	45	10	3
	STVT-1	*Striga* biotype differentials	15	12	3
Breeders and Physiologists	MTSLDR	Potential drought resistances	54	4	3
Pathologists	ISGMN	Grain mold low susceptibles	30	5	20
	ISCRN	Charcoal rot low susceptibles	30	5	8
	ISDMN	SDM low susceptibles	25	2	12
	ISLDN	Leaf disease low susceptibles	30	6	14
	IPVPS	SDM biotype differentials	15	2	9
Entomologists	ISSFN	Shoot fly resistant lines	20	6	7
	ISSBN	Chilo stem borer resistant lines	20	6	3
	ISMN	Midge resistant lines	15	7	4

a/ ICRISAT Center-operated locations and ICRISAT Cooperative Program locations

b/ National program locations

Table 5. ICRISAT coordinated chickpea multilocational trials in 1978-79

Coordinators	Acronym	Description	Entries	locations IC[a]	locations NP[b]
Breeders	ICSN-A	Advanced generation bulked lines - short duration	63	1	12
	ICSN-B	Advanced generation bulked lines - long duration	83	1	16
	ICCT-DS	Elite cultivars - short duration	16	1	9
	ICCT-DL	Elite cultivars - long duration	16	1	12
	ICMT	Exploratory Trial	10	0	3
	F_2 trials	Segregating bulks	176[c]	3	4
Pathologists	ICRRWN	Chickpea Root Rots and Wilt Nursery	63	1	36
	ICABN	Chickpea Ascochyta Blight Nursery	46	1	12

[a] ICRISAT Center-operated locations and ICRISAT Cooperative Program locations

[b] National program locations

[c] These are total number of entries for four separate trials

Table 6. ICRISAT coordinated pigeonpea multilocational trials in 1978-79

Coordinators	Acronym	Description	Entries	locations IC[a/]	locations NP[b/]
Breeders	SMRT	Sterility Mosaic Resistant lines Test	15	1	5
	VPPIT-1	Vegetable Type Pigeonpea Trial - Early types	18	1	11
	VPPIT-2	Vegetable Type Pigeonpea Trial - Medial and Late types	28	1	7
Pathologists	PWN	Pigeonpea Wilt Nursery	14	2	8
	PSMN	Pigeonpea Sterility Mosaic Nursery	20	1	8

a/ ICRISAT Center-operated locations and ICRISAT Cooperative Program locations

b/ National program locations

Table 7. ICRISAT coordinated groundnut multilocational trials in 1979

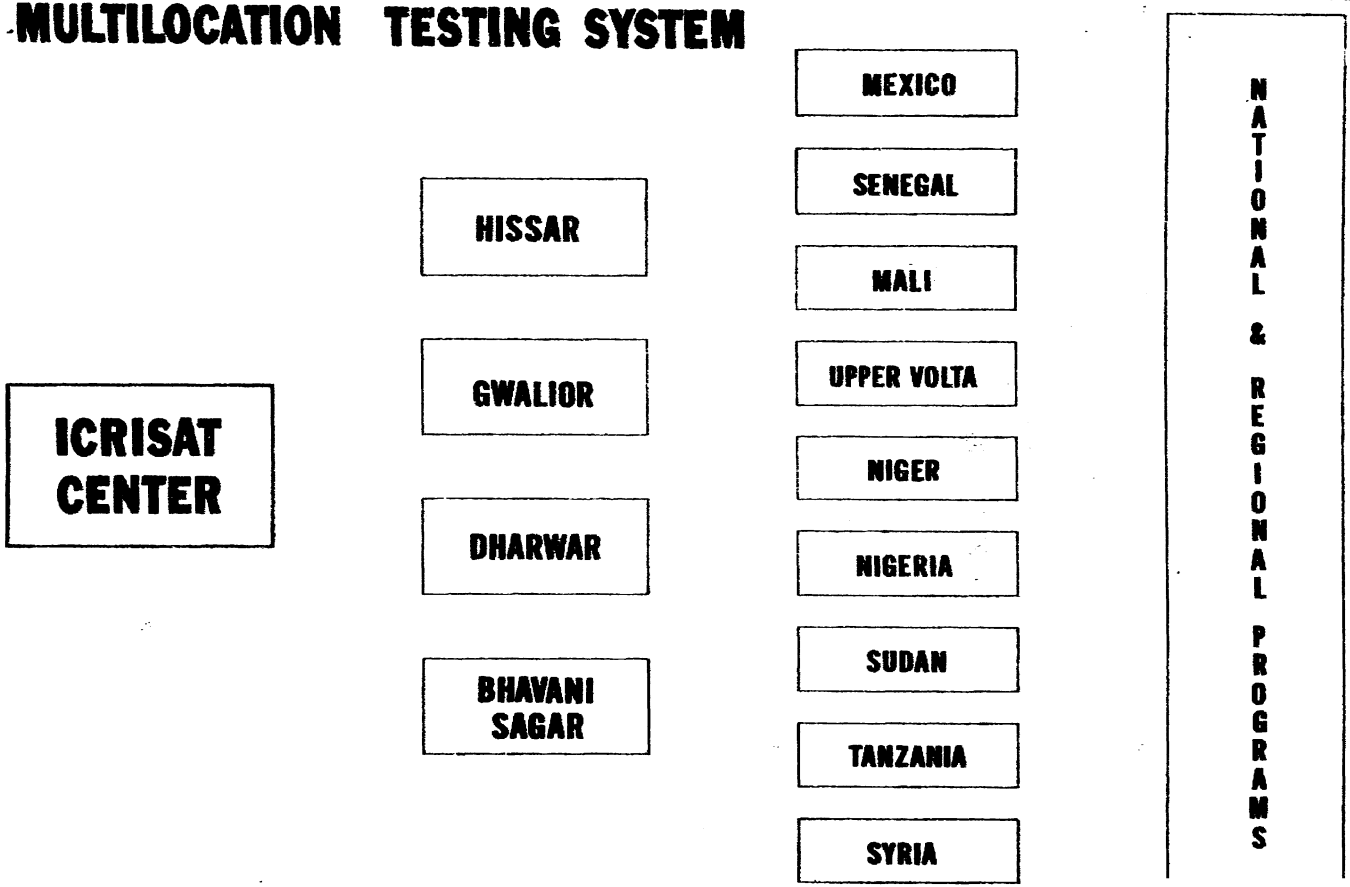
Coordinators	Acronym	Description	Entries	locations IC[a/]	locations NP[b/]
Breeders	ICYT	Advanced yield trial	49	2	2
Pathologists	PGLDT-1	Cercospora leaf spot resistance sources	60	1	2
	PGLDT-2	Rust and leaft spot resistance	31	1	11
	-	Location of resistance to "clump" disease	132	0[c/]	2

a/ ICRISAT Center

b/ National program locations

c/ "Clump" does not occur at ICRISAT Center

COMPONENTS IN THE ICRISAT CROP IMPROVEMENT PROGRAMS' MULTILOCATION TESTING SYSTEM



APPENDIX I

1. COMPUTERIZED PLANNING OF EXPERIMENTS

A capability for randomizing for field or laboratory experiments, printing labels for seed packets, printing of field books, and creation of standard data files from stored randomizations has been implemented through a set of commands under CRISP (Crops Research Integrated Statistical Package). Each of the commands will now be discussed below.

FLDINIT - command to initialize a randomization file for an experiment

The dialogue under this command is similar to that of command SETUP for the creation of a standard data file. The user must supply a file name (up to 6 characters) and an extension of .RND will be added to this name to identify the file as a randomization file. The entry of the name of the experiment, date or season, person responsible for the experiment and a description of the experiment (up to 6 lines of 64 characters each including blanks) is required. The first factor for all experimental designs must be replications. The required order for the other factors is given below when each design is individually discussed. An option for copying all of the above information from an existing randomization file also exists under this command. Once the randomization file is initialized a YES response to the question DO YOU WANT TO PERFORM RANDOMIZATIONS NOW? will cause automatic transfer to the experimental design randomizations control program. If you answer NO, you can perform randomizations later through the use of command FLDESIGN.

NOTE: Since the typing of the information required for command FLDINIT is time consuming for large experiments, Computer Services will perform this task for you. A form, "REQUEST FOR RANDOMIZATION FILE INITIALIZATION", is available from Computer Services.

FLDESIGN - command to invoke the randomizations control program

A randomization file created under command FLDINIT is required input. The sub-commands currently available under FLDESIGN are:

RCB randomized complete block design with up to 6 treatment factors and an option for placing systematic checks for the one treatment factor case. The randomization file must have factors in the order replications, and treatment factors in any order. If systematic checks are being used, the checks must appear last in the list of treatments and a different name must be used for each occurrence of the same check within a replication. For example, if there will be five check plots in each replication with the same check variety, then they should appear as the last five treatments as CHECK-1, CHECK-2,... CHECK-5. The unique names are necessary to distinguish plots at the time of analysis. The user must specify the plot numbers to be used for the systematic checks.

RCBGRP randomized complete block design with grouped treatments. The user can define groups in a single treatment factor experiment and the members of the group will be randomized together within each replication. If systematic checks are being used, then the check treatments must be defined as the last group. The sizes of these groups are specified at the time of randomization. The members of the groups must be stored contiguously in the list of entries. The randomization file must have factors defined in the order replication, groups, and treatments.

SPLIT split plot design with main plots in an RCB design. The current implementation provides randomizations for one mainplot factor and one subplot factor only. The randomization file must have factors defined in the order replications subplots, mainplots.

LATTICE simple, triple or balanced lattice design. Only one treatment factor is permitted. The randomization file must have factors defined in the order replications, blocks, treatments. A 20 x 20 lattice is the maximum size possible for a simple lattice, a 12 x 12 lattice is the maximum triple lattice and a 9 x 9 lattice is the maximum balanced lattice. The type of lattice to be randomized will be determined from the number of replications and blocks in the randomization file.

NURSERY unreplicated nursery trial. The randomization file must have one factor defined for varieties. If systemmatic checks are being used, then the checks must appear last in the list of varieties.

For example, in a trial with 100 varieties, 3 of which are check varieties, the check varieties must be numbered 98-100. Each check will be repeated in equally spaced plots as specified by the user. Randomization of the test varieties is optional. If randomization is not selected, then varieties are assigned to plots in the order of their definition in the randomization file.

The randomization routines have provision for a maximum of 500 experimental units over 50 locations. The location names (maximum 16 characters) are entered under this command and stored in the randomization file. A new randomization is performed for each location and stored in the randomization file. The user has the option of assigning the experimental unit (plot) numbers or having them generated by the program. If automatic generation of numbers is selected, then the user has the option of 3-digit or 4-digit plot numbers. First the plots within a replication are numbered from 1 to the number of treatments or treatment combinations. The replication number times 100 or times 1000, depending of the usage of 3-digit or 4-digit plot numbers, is then added to each plot number to get the final plot numbers. The same numbering system is used for each location. If the user chooses to assign plot numbers, then the number to be assigned to the first plot must be entered. Plots are numbered sequentially, starting with the user-supplied plot number, from the first plot of the first replication of the first location to the last plot of the last replication of the last location. The output for each location consists of the treatment number, treatment name and the experimental unit (plot) numbers assigned to the treatment within all replications on each line. In the case of a multi-treatment factor experiment, the treatment combinations are numbered from one to the total number of combinations and the treatment combination names are printed on each line. The randomization output can be directed to the terminal or to a print file for subsequent printing on the line printer.

Once the randomization is complete, the user is given the option of transferring control to the seed packet label generation routine. If labels are not required, then the user may optionally select one of the field book generation options. Alternatively, label generation may be selected at a later time using command FIDLABEL and field books can be generated using one of the three field book commands.

FLDLABEL - command to generate a print file of seed packet labels from a randomization file

The randomization file used as input must have been completed by one of the randomization routines before labels

can be generated. The labels printed are grouped by entry number; i.e., all of the labels for entry 1 are printed first followed by all of the labels for entry 2, etc. Each label consists of three lines: line 1 contains an abbreviated experiment name followed by the location name; line 2 contains the entry number and optionally the entry name and line 3 contains the plot number. In the case of a multi-treatment factor experiment, the user must select which treatment factor is to appear on each label. Once the label routine is completed, the name of the label print file will be printed. Since the printing of labels requires disruption of the normal line printer usage, please make arrangements with Computer Services for printing of your labels during the evening shift. The user is given the option of transferring control to one of the field book generation routines.

FLDBOOK1 - command to generate a type-1 field book

The type-1 field book routine produces a field book from a randomization file and user supplied column headings. Each line of a heading must not exceed 8 characters and it is recommended that no more that two lines be used for any one colum heading. The headings are printed horizontally acro the page. The width of each column on a page is ... by the user, but may be made wider to accommodate ...umn heading. The total width of a field book page exceed 95 spaces. The first two columns of each page ...ts of the plot number and the treatment number, r...spectively. In the case of user-assigned plot numbers, the second column may optionally contain a coded number which represents the factor settings of all the factors for the associated plot. For example, in an experiment with two replications and two treatment factors, the number 10515 could represent replication 1; treatment factor 1, level 5; and treatment factor 2, level 15. The user may also select the number of plots to appear on each page of the field book. Since it is possible that different headings are required for different locations, the user must select the range of locations which require field books with the current set of headings. Once the field book file is complete, it may be queued for printing. However, if your field book file is very large, please arrange with Computer Services for its printing during the evening shift.

FLDBOOK2 - command to generate a type-2 field book

The type-2 field book routine produces a field book from a randomization file and user supplied column headings. The column headings must be limited to two lines of 15 characters each. The headings are printed upward and toward

the right of the page. The rest of the options available are the same as for the type-1 field book.

FLDSETUP - command to initialize a data file from a randomization file

A completed randomization file is the required input for this command. Identifiers and factors are automatically copied to the data file. Since only data from a single location can be stored in one data file, the user must select the location name from those stored in the randomization file. The location name is appended to the date of the experiment in the data file. The randomization file contains the factor settings required in each row of the data file. The plot number will be automatically stored as the first variable in the data file. The names, abbreviations, and descriptions of all variables to be stored in the data file must be entered at this time. This information may also be optionally copied from an existing data file. If you choose the copying option, be certain not to copy the plot number variable since it will be automatically included as explained above. Once the file is initialized control is transferred to the "add rows" option of the data entry subsystem.

Note: Since there may be considerable time between the creation of the randomization file and the initialization of the data file, it is recommended that the randomization files be stored on magnetic tape and subsequently removed from the disk. They can be restored to disk as needed.

II. DATA ANALYSES

The Crops Research Integrated Research Statistical Package (CRISP) of programs contains a wide range of data analysis, data editing, and utility programs. Many of these, such as various analyses of variance, regression, correlation programs are of general use while some have been developed specifically in response to problems of handling the data from the multilocational testing. For example INCDNC was developed in response to a request from the pearl millet pathology group to convert the raw data on numbers of plants infected with various severities of downy mildew into the two needed variables "incidence" and "infection index". Other programs of more general use for handling multilocational test data are MULMERGE, for combining the data sets for one trial from many locations, and SELECT, which performs the rapid selection of entries that meet a specified combination of levels of up to thirty variables.

CRISP can be summarized as follows:

1. Each analysis is initiated by specifying a command name

2. A common file structure is used by all analyses in the package

3. A file maintenance subsystem is available for editing user data files.

The following types of analyses are available under CRISP.

1. Distribution Analysis

2. Correlation Analysis (Simple & Partial)

3. Analysis of Variance (18 different types)

4. Analysis of Covariance (3 different types)

5. Regression (Multiple, Polynomial, Stepwise)

6. Printer Plotting

7. t-test

Most analyses have the option of either printing the output on the terminal or on the line printer.

The following types of file utility operations can be performed.

1. Ranking of data in a file

2. Reordering the factors in a file

3. Averaging data over one or more factors

4. Subdividing a variable into new variables according to the levels of a factor

5. Mathematical transformations of data

6. Merging of files to form new files

7. Selecting subsets of data based on logical combinations of conditions imposed on the data