

THE ROLE OF AN INTERNATIONAL INSTITUTE IN FARMING SYSTEMS RESEARCH

Hans P. Binswanger

and

S.M. Virmani

INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS
HYDERABAD 500-016, INDIA
November 1975

CONFIDENTIAL PRELIMINARY DRAFT FOR
DISCUSSION PURPOSES ONLY

THE ROLE OF AN INTERNATIONAL INSTITUTE IN FARMING SYSTEMS
RESEARCH

Hans P. Binswanger and S.M. Virmani

This note is intended to serve as a basis for a thorough discussion about the role of an International Institute such as ICRISAT in the area of Farming Systems Research. As such it is very tentative and the ideas expressed need scrutiny, qualification and amplification by researchers inside and outside of the International system. However the issues involved are of extreme importance for the successful allocation of research resources and research tasks within the international system and between the national and international systems.

BASIC CONSIDERATION

Regardless in what specific words one defines a farming system, research in this area has the goal to derive a set of agronomic, soil preparation, soil and water conservation and drainage practices for a mix of crops, for given soil and climatic characteristics which are extremely location specific. Upto the inception of the All India Coordinated Research Project for Dryland Agriculture (AICRPDA) such research was done in various programs for individual locations independently in the Semi-Arid

of India

Tropics/ AICRPDA is the first effort to coordinate such research both disciplinewise and over a vast geographic area, and to systematically exploit whatever geographic transferability of research results exist. ICRISAT has been superimposed on this effort on an international scale but does not have a system of widespread branch stations which AICRPDA has *in India*

Location Specificity

The location specificity of farming systems is probably the most important factor which governs what an international research institute can and should do. Clearly it implies that such an institute without branch stations in every agro-ecological niche (which ICRISAT will never try to have) cannot and should not be concerned with research whose results are so location specific that transfer to other ecological areas is impossible. Instead, our basic hypothesis is that the international institute should be concerned with the development and dissemination of research results which are transferable and which are capable of speeding up the development of location specific farming systems by national and local research centers. Hence the question becomes which components of knowledge are transferable. It is useful in this context to briefly digress on the similar issues faced in varietal research.

uni locational trials with changed environments.

The success of IRRI and CYMMIT is based on the geographic transferability of knowledge in genetics, plant physiology, pathology and microbiology and on the transferability of germ-plasm. Even knowledge and germ-plasms are not perfectly transferable but they are much more so than varieties¹. While transfer of varieties was important in the initial stages of the green revolution, the varieties of the international centers are now largely displaced by follow up varieties developed by national programs which incorporate germ-plasms from the international centers. Furthermore, it has been shown that even the transfer of varieties and much more so the breeding of follow up varieties has been primarily to areas which had reasonably strong domestic and regional research programs. Countries without a domestic research capability have largely been unable to benefit from the green revolution². The transfer of a research methodology to the national institutes thus appears crucial. Even in varietal research, transfer of technology has been difficult and conditional on local adaptive and original research.

1 For a more thorough discussion see R.E. Evenson and H.P. Binswanger "Research Resource Allocation and Technology Transfer" in Binswanger and Ruttan : Induced Innovation: Technology Institutions and Development (Baltimore, Johns Hopkins Press, 1976).

2 For empirical evidence see Evenson and Binswanger, Op. Cit.

What then are the components of farming systems knowledge and technology which can be expected to be transferable.

- (1) Research methodology and research designs;
- (2) Basic or supportive knowledge in the areas of agronomy, physiology, hydrology, soil science, agroclimatology, etc. As an example, basic principles of inter-crop competition for light, water and nutrients should be highly transferable but an optimal cropmix in one location is unlikely to be useful in strongly different ecological zones.
- (3) Applied knowledge, specific recommendations and components of farming system technology are likely to be transferable between zones and regions with highly similar ecological features and similar economic factors such as farm size, population density, etc. It is conceivable that some location specific practices found in an AICRPDA Research Station or elsewhere in India may be useful in similar agroclimatic region in Africa or South America, although economic and social factors may reduce transferability of some results even if agroclimatically they would fit.

The Problem of Focussing Research

The second basic consideration has to do with the efficiency of the actual research process. Research is search for additional knowledge and for practices in an almost infinite space of not yet discovered knowledge on the behavior of species, varieties, potential practices and combination of practices in any given agro-climatological zone. If such search is carried out at random the probability that it will lead to useful knowledge and successful practices is very small indeed. Researchers, of course, do not search at random. Instead, they are guided by

the goal of achieving a given specific result, by disciplinary knowledge, by previous research and farming experience, by knowledge of the literature, and by a fair amount of intuition. On the basis of this, the biological and physical researcher designs his research strategy and experiments. But even for the most efficient researchers, the number of possible experiments is still very large. Furthermore, the experimentation is costly, and very time-consuming, especially in an environment where climatic variability from year to year is as large as in the Semi-Arid Tropics¹. One goal of an international institute and also of a national coordinating cell (such as AICRPDA) should be to help the local researcher narrow down the set of practices actually tried in experiments to the most promising ones so that he does not spend time and resources on experimenting with practices which later are shown as infeasible because of climatic conditions, non-profitability, unavailability of labor at given seasons etc. This can be achieved again by providing the local researchers with fast access to basic knowledge, research results in similar ecological zones and information on climatic and economic constraints for crops, varieties and practices among which he should choose to experiment.

*of the things
are so much
location
specific,
practices can
not be managed
down unless
they have
been reported
in detail with
in each location*

¹ For example in Hyderabad region the seasonal monsoon rainfall varies from 300 to 1400 mm with a mean deviation of 160 mm. The growing season could be as short as 80 days and as long as 160 days. With a proper recycling of water it could extend to about 250 days. The coefficient of variation with respect to annual rainfall in semi-arid tropical India varies from 10 to 40%. All these factors tend to destabilize the experimental results from year to year and make it difficult to arrive at conclusions for applicability in a short period of time.

We can consider the crops, varieties and practices which are potentially applicable to some ecological zones of the semi-arid tropics as defining the set S of potential experiments which a local research station might consider. This set is extremely large. We can further define the set of experiments which will successfully identify a crop, variety or practice for a specific local area, as the set T (of course we can only define it, not know it; otherwise we would have all the answers). The set T is likely to a small subset of S because it has to satisfy the local climatological conditions, soil types, pest and disease pressures and economic constraints. Random research in the set S will result in a very small probability of finding a point in T, and figure 1 shows this graphically.

not clear

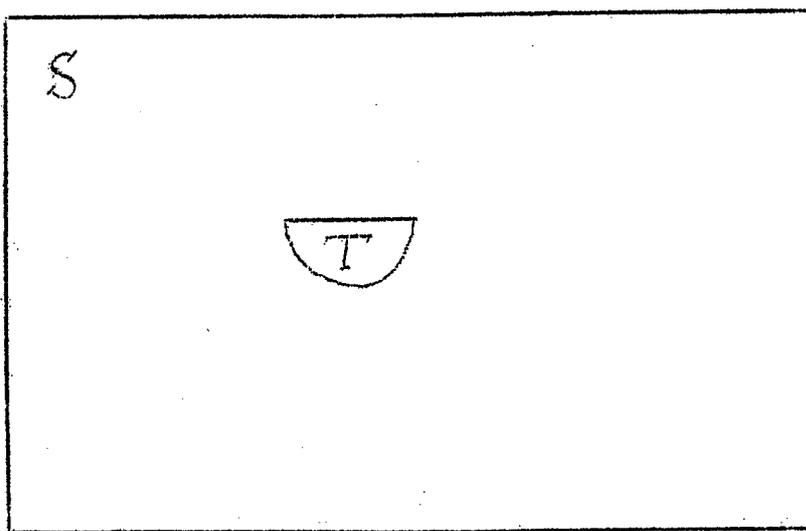


Figure 1

However it is relatively easy to get data on climates, soils and some economic constraints by ecological zones. It is also possible to derive water use relationships of crops and plants experimentally, i.e. to determine how much water they need at any given point of their growing cycle. With this information it is possible to exclude a number of experiments as not worthwhile because they have no chance of being successful on either climatological, soils or economic grounds. This can be done using fairly simple systems analytical approaches. In fact the climate of a region defines a subset of experiments C which could result in a successful new practice, the soils define a subset P, and the profitability considerations and economic constraints define a subset E of experiments which could lead to successful practices on economic grounds. These sets are drawn in figure 2.

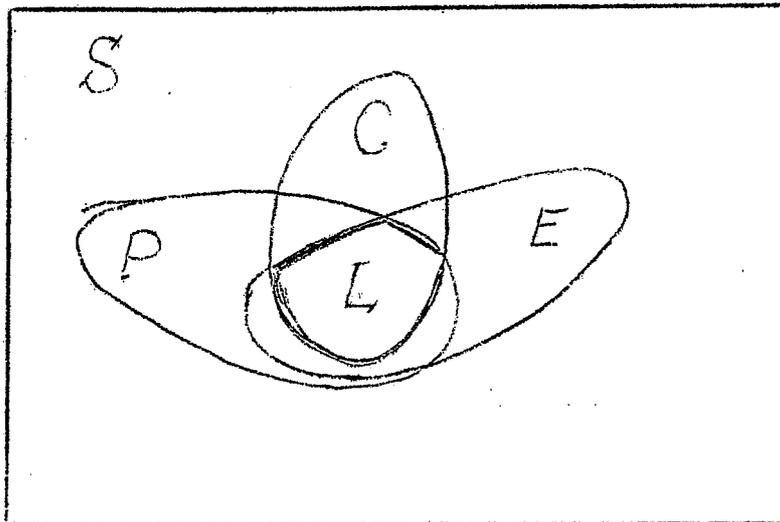


Figure 2

It is only those experiments which on a priori grounds satisfy climatological, soils and economic constraints, i.e. only those in the "Likely" intersection L of the sets P, C and E which are worth trying. (Note that the set L is still larger than the set of successful practices T). The researcher, of course, will always use his knowledge and experience to attempt to conduct only experiments in L. But we should recognize that especially the successful researchers are frequently transferred from one area to another or one task to another. And for all researchers to experience a full range of climatic conditions in any given area takes a number of years, as our experience at ICRISAT has shown.

policy
matter
not in
effect
of his approval
but that of
policy

If we were successful in providing a systematic approach of screening the available climatological, soil type, and economic information, we could perform an important service to the local stations and provide them with a set of crops, varieties and practices such as L which is not inconsistent on the basis of existing knowledge with the local conditions.

↓
this is
not static

A researcher who is given a reduced set L, will always be able to further reduce it by additional knowledge and experience which he has about the local farming conditions even before he starts doing research.

Such a systematic approach of focussing research in no way dispenses with the need for local experimentation because pest and disease pressure and many other local factors cannot be assessed in this way. Which practices of the "Likely" set are actually successful needs to be assessed in experiments. But focussing research on a sharply reduced subset of "Likely" experiments such as L would tremendously speed up the research process and the learning process of researchers. The appendix to this note gives two examples of how this can be done.

Role of International Multilocation Trials

The third basic consideration relates to the role of international and interregional cooperative and standardized trials. Such trials play an extremely important role in varietal research. They are an efficient way to speed up progress, because they generate in one year information about the behavior of a variety in different climatic conditions which would take many years in a single or a few locations.

Any local research station will want to test a large set of varieties in such international trials because, even if a variety is not locally adapted, it may later want to use it in its local breeding program as a parent.

For Farming Systems the basic advantage of multilocation trials would be the same. If a trial is run in two similar ecological zones and the weather in a given year differs for the two locations, information is found about the behavior under two climatic conditions which a practice might encounter in any single region. Since the climatic variability at any location in the SAT is large, a suitably designed multilocation experiment might provide information about the behavior of a practice over a whole weather cycle in one or two years rather than six or seven. This in fact is one basic rationale for the AICRPDA program and already current practice in India. Extension to the international scale should be attempted.

There is, however, one basic difference between Farming Systems knowledge and varieties. Practices and crop mixes are extremely diversified across ecological zones. A local breeder is interested in the local performance of a variety even if he knows a priori that it will never work there, because it could still be used as a parent. An agronomist has no interest in testing practices for which he knows a priori that it would not work. International Cooperative Trials therefore should be run separately for different ecological conditions. We need to divide the SAT into subzones of similar characteristics (isoclines) and internationally identify the areas falling in each subzone. Stations in each of the subzones can then be grouped for a reduced set of standardized trials which are of interest only to the particular subzone. Doing this on an international basis would have an additional advantage. In any given year similar ecological zones of even a large country such as India are likely to experience similar weather conditions, as the 1975 kharif has shown. The weather variability across stations within a nation is thus sometimes not as large as might be desired. Grouping Indian, African and South American stations of similar ecological subzones would greatly increase the range of weather to which each experiment is subjected in any given year.

At research level it is all right. But not at production level

112

IMPLICATION FOR FARMING SYSTEMS RESEARCH AND TRAINING
ACTIVITIES AT ICRISAT

The basic perspective outlined above will lead to a more broad based program at ICRISAT, although many components of the present research need not be changed but put into a different perspective. The following areas of work seem important:

1) Basic or supportive Research on research methodology, agronomy, physiology, crop competition, hydrology, soil science, etc.

One example is the derivation of rainfall-runoff relationships from experiments at several localities under different soil and climate conditions. Using statistical techniques would enable the generation of a predictive model which could be applied to areas with different conditions for which no research results are available. Similarly basic water response relationships of crops would be of high priority. We could also develop basic research designs for applied investigations. Such research cannot all be carried out at our site alone. Contracting out of some basic physiological research is possible. For runoff relationships, cooperation of a few selected research centers is necessary. But by no means does it imply the involvement of a full set of local and national institutions.

2) Provision for gathering and assembling existing base line data in the areas of climatology, soil science, water management, plant protection and economics.

This would be required for a better understanding of the reasons why traditional farming practices prevail in certain areas as well as for evaluating the technical and economic feasibility of introducing improved systems in any given area for which base data have been assembled. It could also include the detection and definition of traditionally established practices for transfer from one area to another, where similar conditions exist.

3) International assembly and communication of basic and applied research results.

This would be a service function to national research institutions. It should include an interpretation of the research results as well and not merely be an abstracting and library kind of work. Ideally a local research center should be able to enquire whether results on a particular practice, which it wants to try, are available from elsewhere and receive a summary of such results very quickly. On the basis of this it could decide much better whether actually to experiment or not¹. Particular emphasis should be given to the establishment of international information flows of applied results among similar ecological zones².

1 In India, the Institute for Agricultural Research Statistics (IARS) is performing a similar function for India alone. ICRISAT would do the international part and might collaborate with IARS in the Indian part.

2 This would probably involve the effort of one full scientist.

4) Systems-analytic studies on Research Priorities

based on soil, disease and economic constraints to cropping patterns, cultivation practices, soil conservation practices and irrigation strategy.

The goal of these studies would specifically be to provide national research stations with a clearly defined set of crops and practices which it is worth experimenting on. Such systems analytical studies will never be able to check whether a crop will actually perform well in a given area. This has to be done locally. But it can give a set of crops and practices to which no a priori constraints exist on ecological and economic grounds. The local station starting experimenting can then start from a much reduced set of practices.

It has to be stressed that these system analytical models do require the basic or supportive knowledge mentioned under point one and two. The examples of studies already under way in this area are given in the Appendix.

5) The organization of international cooperative trials for several groups of research stations in homo-ecological zones.

Research designs for such experiments could come from local stations, AICRPDA, and ICRISAT and would have to be planned in close collaboration with them.

6) Actual development of Farming Systems for selected areas. The primary purpose of such research would not be the development of the actual Farming Systems for Hyderabad or Samaru. Both these regions are already national agricultural research centers and not deprived of local research, as many other areas or countries are. However we do need this applied kind of research to test out our methodological approaches, the usefulness of the basic knowledge generated and of the various systems models of research planning. We also need it for training purposes of researchers and for demonstration purposes. However two or three locations are probably enough.

This applied research would stand on three legs: Small plot trials, Watershed based trials, and Trials in Farmers fields.

7) Training of researchers for National Research Institutes. ICRISAT should primarily be a training Center in Farming Systems Research Methodology and in basic knowledge related to Farming Systems. We are already training personnel for national production programs and campaigns. We may also contemplate training programs for soil conservation and irrigation personnel.

This may continue to be an important training function, but the following points need serious consideration :

- a) Our training capacity for national production programs is extremely limited. If we can accommodate 20 trainees in the production program area, it will be much. A trainer's training program is all we can hope for.
- b) India has many training institutes which can and should handle this area. Our primary emphasis in this needs to be on Africa.
- c) African trainees confront a major cultural barrier and frequently a language barrier. Training of African production program people in Farming Systems might be better done in Africa in the long run. Researchers' training may still have to be done in Hyderabad.

PROBLEMS OF COLLABORATION WITH NATIONAL AND REGIONAL RESEARCH
INSTITUTES AND AGENCIES

The approach outlined above involves a minimal amount of overlapping and competition with National Institutes and a maximum amount of complementarity. The responsibility for location specific development of Farming Systems is on the National and Regional Centers and the credit for doing this work will always be theirs'. ICRISAT's function should primarily be a research support and communication function. Most of the African Nations will, for a long time to come, have to rely for such basic

support on the International Research System. Our training function has to be geared to build up their capacity to utilize this support and to do the location specific work.

In India the situation is more complex. India does have the capacity for the location specific work, and for a substantial amount of the supportive work and training of researchers. Some of the support functions mentioned above are already carried out by AICRPDA, IARS, and some basic research is done in Universities and other Research Institutes as well. ICRISAT should complement this effort in those areas where international cooperation is essential. Furthermore, basic research which needs to be carried out internationally and methodological and systems analytical work which is applicable both to India and other countries can usefully be left to ICRISAT in close collaboration with the coordinating Indian programs. The precise division of labor will have to be worked out in close consultation with them.

APPENDIX

EXAMPLES OF SYSTEMS ANALYTICAL APPROACHES TO RESEARCH PLANNING

The Farming Systems Program, together with Dr. Virmani, Agroclimatologist and Drs. Ryan and von Oppen, Economists have started to activities which can give an idea of approaches, methods and data needs for studies in this area¹.

The Use of Agro-Climatic Studies in Crop Planning

Evaluation of long term rainfall data using Markov chain analysis techniques and water balance² studies based on soil, potential evapotranspiration and rainfall would yield information on the frequency of drought and of excess of water over the growing period. Such an analysis can be carried out over a broad spectrum of EA/PE². Selection of crops and varieties can be made by matching the growth curves with the water availability probabilities. A preliminary analysis of Hyderabad rainfall data over 70 years

¹ S.M. Virmani, "Evaluation of Agricultural Climate of Hyderabad Region with reference to Crop Planning", Paper given at the ICRISAT Farming Systems Seminar, November 1975.

James G. Ryan and M. von Oppen, "Outline of a Model to Estimate Returns from Water Harvesting and Supplementary Irrigation" (ICRISAT, Economics Department, March 1975).

² Actual/Potential evapotranspiration.

combined with water balance studies showed that on all soil types a 120-140 day base crop combined with a short duration inter-crop is likely to confront the smallest probabilities of adverse weather¹. In the red soils where the inter-seasonal probability of drought is higher, an indeterminate crop or crops with a long-spread out flowering period (eg. groundnut, castor) may suit better compared to a determinate crop which may be suitable for intermediate and black soils.

The analysis of the probability of dry or wet spells in the growing period or wet periods followed by wet periods in the case of extended rainfall seasons, could help in crop planning by choosing crops that would avoid both and also in devising plant management techniques (eg. harvesting of sorghum for fodder prior to boot stage and ratooning it for extending crop life) and agronomic techniques (fertilizer application etc.) suited to the agro-climate.

Projections on the suitability of cropping seasons for stabilizing agricultural production can also be made by evaluating dependability of short-term rainfall (5-day or weekly) at some pre-specified rainfall levels (0.5 to 0.8 of Potential Evapotranspiration). Such an analysis for example showed that in the deep soil regions of Sholapur with relatively undependable rainfall kharif following followed by rabi cropping may be the best practice which farmers can do with the existing crop varieties. However

1 Virmani, Op. Cit.

in the shallow soil areas of Akola and Hyderabad which have fairly dependable rainfall kharif cropping is already feasible. And in areas with dependable rainfall and deep soils kharif cropping followed by sequential cropping into rabi season may be most efficient.

A much more detailed analysis of the soil-climate based on long-term meteorological data for Hyderabad region which will be richer in implications is being compiled. Once the methodology is fully developed program packages will be created. Then similar studies can be initiated for other areas of interest to ICRISAT.

Evaluation of the Suitability of Run-Off Collection Tanks

In the area of tank irrigation for the purpose of breaking of intraseasonal droughts and to extend the cropping season beyond the monsoon season the likely benefits of tanks are highly dependent on the relationship of probabilities of rainfall, runoff and drought¹. These relationships will differ strongly among areas. Probability distributions of rainfall jointly with runoff relationships determine a probability distribution of water levels in a tank. The conditional probability of a drought given that sufficient irrigation water is available, together with the moisture retention capability of the soils determine how frequently the benefits from breaking a drought will accrue. The higher the frequency, the larger the benefits of tanks in a region. The probability distribution of water levels at the end of the monsoon, together

1 Ryan and von Oppen, Op. Cit.

with soil moisture status and retention capability at the end of the monsoon season, determines the benefits from extending the cropping season. Weather, runoff and soil moisture retention capability at any given location thus determine the expected benefits from Tanks. Experimentation with and construction of tanks should be confined to those areas where rainfall patterns and soil types are such that high payoff can be anticipated¹. A simulation model based on basic knowledge of runoff relationships, water retention relationships, water consumptions by plants is being constructed now for the purpose of identifying the semi-arid tropical areas with high payoff of tank irrigation.

HPB/SMV/ purna.

1 A preliminary analysis of rainfall data shows that in Semi-Arid India, Tanks seem to be concentrated most where probabilities of breaking droughts appear highest.