PROCEEDINGS OF THE GLOBAL INHOUSE REVIEW

RESOURCE MANAGEMENT PROGRAM

(ICRISAT CENTER AND ISC)

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics

ICRISAT Patancheru P.O. Andhra Pradesh 502 324, India

November 13-15, 1989

RESOURCE MANAGEMENT PROGRAM IN-HOUSE REVIEW - 1989

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PREFACE

The Global Review of the Resource Management Program held in November, 1989, differed from previous reviews in several significant respects. Little time was spent reviewing progress since the last review because we wished to focus on the future. As part of its input to the Institute's strategic planning exercise, the Program set out to take a broad view of its responsibilities throughout the semi-arid tropics and to start planning the pattern of experimentation and survey needed over the next decade to identify and reduce constraints to production. Within this pattern, we identified four themes which were reviewed and discussed in consecutive sessions: Characterization and Evaluation of Resources; Measurement and Management of Constraints; Improvement of Production Systems; and the Assessment of Technology, Markets and Institutions.

The Program was pleased that four observers familiar with its work were able to attend all sessions of the Review, to act as Chairmen, and to participate in discussions: Dr. I.P. Abrol and Dr. R.P. Singh of the Indian Council of Agricultural Research, Professor J. Elston of the University of Leeds, and Dr. R. Chambers currently based at the Administrative Staff College, Hyderabad.

At least half of each session was allocated for discussion which was always wide-ranging and lively - sometimes very lively! Consensus was reached on several issues but others remain to be resolved within the Program before it faces the External Program Review towards the end of 1990.

I am grateful to the rapporteurs for summaries of presentations and discussions, to Dr. K.B. Laryea who undertook responsibility for editing the whole proceedings and to Mr. P.N. Murthy who typed the proceedings.

December 22, 1989

J.L. Monteith
Director
Resource Management Program

Recommendations

1. The chapter in ICRISAT Strategic plan dealing with environment research should be revised to include (i) residue management, (ii) impact of pests and diseases on adoption of technology, (iii) the role of women in agriculture and (iv) farming systems perspectives in the execution of research.

2. RMP should seize upon the existence of AGLN's work plans and work RMP projects and training into them.

3. To strengthen research both with NARSs and with ILCA, i.e. RMP should develop a 5 special projects for Applied/Adaptive research on Vertisols in Ethiopia.

4. In West Africa, regional demand for technology will be related to stress avoiding, stress tolerant cultivars with acceptable postharvest and consumer characteristics. Future investment in land conserving technologies would be considered. RMP should assess the scope for introducing new crop species in the Sahelian zone if they can reduce the unit cost of labor. As most of agricultural intensification in West Africa will take place at the bottom of the toposequence research should concentrate on this regime, particularly in terms of drainage.

5. In India's semi-arid tropics we should work on rainfed production in higher potential environments. In those areas where rainfall is inadequate but irrigation is available, we need to work on water responses because some of our crops, e.g. short duration pigeonpea, may be popular in these zones. In poor production environments, research should focus on well-defined cropping systems, eg. either production under receding moisture with postrainy season sorghum or chickpea and/or pearl millet production on sandy soils of Rajasthan.

6. There is an urgent need to develop an integrated approach to both soil and crop-related constraints to production. The work of Agronomy and Soil Groups should be more closely related and wherever possible the Groups should collaborate on projects.

7. An interdisciplinary team should be constituted to tackle the problem of soil and crop variability at ISC since it appears the problem is associated with many factors such as nutrient disorder, nematodes, physical heterogeneity etc.

8. An interdisciplinary team involving soil physicists, physiologists, plant pathologists and entomologists should be formed to tackle the problems of seedling establishment at IC.

9. Soil biology unit should help with the work on soil organic matter, its quality and biology of soils at ISC using the

DDG's Africa fund.

10. There should be further discussion among RMP scientists to resolve disagreement and uncertainties raised during this Global review. The major question is not the identification of broad research thrusts but how to translate them into action.

PART 1 : INTRODUCTORY SESSION

Opening Remarks to Global In-House Review
Resource Management Program

13 November 1989

L.D. Swindale

Good morning. Welcome to this Global In-House Review of RMP. It comes at a critical but also most opportune time in the Institute when we are deep in the development of the Institute Strategic Plan. I am sure that we will need major revision of the first draft of the Plan after you have finished your deliberations.

In the year 2000 the world will be a very different place from what it is today - or was yesterday. Look at what is hapenning in Eastern Europe. With such great changes afoot there is ample justification for a Strategic Planning approach. I hope you have all seen either the Approach paper to our Strategic Plan or one of the early drafts. Let me remind you of its major points:

1. Global growth rates will tend to be higher than in recent years and Asia will be in the lead.

2. Concerns for the environment will be great.

3. Asia will be changing fast - we must help it diversify its agriculture.

4. Africa is likely still to be struggling but some countries will be doing much better than today.

5. The CGIAR will still be in business.

It will be larger through the inclusion of more centers and the inclusion of forestry. It will continue to be distinguished by concerns for both efficiency and equity. As Dr. Mashler reminded us on Friday, the CGIAR provides a unique and essential scientific and humanitarian service to the peoples of the developing world.

It will add concerns for sustainability and women's issues. It has a growing concern that the weaknesses of NARS reduce our effectiveness. Resource management scientists must concern themselves with the following criteria and issues:

Short or long term, strategic, applied, or adaptive research processes and products, efficiency and equity, NARS and WID and sustainability, high and low inputs, desirability, feasibility, comparative advantage and impact. Where and in what proportions to apply our resources and whether on soils, water, crops, climate, people or all of them together. We must have quality science - and I stress this because it really is important - but we must be multidisciplinary. We must concern ourselves with the

training needs for NARS scientists inherent in our research, programs, and outputs.

If this all sounds like a rather tall order, please take heart. The two chapters in the Strategic Plan on Environment Research and Assessment Research cover nearly all of these issues and criteria. If you follow the course plotted in the Environment Research chapter and answer those questions in the Assessment chapter that are relevant to your Programs you should be in great shape. Also, if you apply those chapters thoughtfully and critically, there should be lots of terminating projects, new ones and a considerable overall improvement in quality and focus. In just a few places the balance in those two chapters doesn't seem quite right.

1. There is virtually no mention of residue management and the importance of soil organic manure. We are working mostly with soils with poor structure and organic manure is important to their performance.

2. More stress needs to be given to pests and diseases. Not only in modelling and component research but in assessing the impact of pests and diseases on adoption of technology. Bert Krantz preferred to adopt an escape mechanism to the problem of sorghum grain mold - he utilized maize in his cropping systems. A legitimate strategy and one that seems to me to be working. Lots more maize on the plains than there was 10 years ago.

3. There is no consideration of the role of women. I hope that your viewing of the video on African Agriculture tomorrow will improve your understanding of this important issue.

4. There is barely a mention of farming systems and no indication that you intend to utilize any farming systems perspectives or approaches. This must surely be corrected. The emphasis on strategic research, and processes, and feasibility seems to be a recipe for Ivory Towerism. You will need ... to keep your feet on the ground, or if you prefer, your roots in the soil.

   The farming system concept also contains elements of both ex-ante and ex-post evaluation and helps answer at least partially the question posed about these two approaches in the Assessment paper. It also relates to what the Governing Board says about the continuum of Research and TOT which I will mention later. It relates to a concern that I have that we do not yet have strong methodological links between one type of research and the next, eg. between strategic and applied, between components and their synthesis, between climate research and cropping systems and operational scale studies.

5. On another subject we certainly do need to give adequate weight to feasibility as a research criterion but for all

sorts of reasons we must not let it dominate our decisions. We are not going to pull out of the rainfed SAT. Where would we all go? CIMMYT is probably the only center left in the system that lets considerations of feasibility and efficiency dominate its decision-making and it doesn't have room for us all. So let us not overlook the systems humanitarian goals.

Last week for 3 days the Governing Board considered the first draft of our Strategic Plan. They made these comments:

1. Our Center should be one of scientific excellence.

2. Research should be closely tied to practical demands - Objective Basic Research = Strategic Research.

3. Research and TOT are a continuum - and - I would add - ICRISAT RMP must operate all along it changing its sectors of concentration at different times.

4. Objectives of Program (Thrusts) if not of projects should cite quantitative goals.

5. Staff from scientists on down should be willing to think and act in an interdisciplinary way - that is they should be able to operate both within and without their narrow disciplines.

6. In West Africa: Board Members who know the region consider that Government policies and lack of infrastructure are more limiting than absence of physiological and biological technology - How does that view square with the progress made by our small bilateral team? If Dr. Shetty and colleagues agree, what does that mean for the role of the Economist in WASIP-Mali and the three economists at ISC.

7. A closely related issue is working with the NARS. Firstly in West Africa. Africa Task Force rejected our OPSCAR. They agreed that it was a useful program but concluded that it did not meet their requirements of being a NARS generated project - it was an ICRISAT generated project. Do we want to do anything about this?

   Secondly at IC. Here I see much need for improvement. We have recently worked out our Annual Plan with Indian institutions which remains to be implemented. For the rest of Asia we should seize upon the existence of AGLN's work plans and work RMP projects and training into them.

8. Should we concentrate on working with strong or weak NARS? The Board discussed this but could not reach a decision. Thinking about it over the weekend I have decided it is a non-issue. We find ways to work with all NARS. And in West Africa none can really be called strong.

9. To what extent will we finance the NARS so they can work with us. I think this is a question for RMP. We do this already

in our commodity programs but not in RMP except perhaps some assistance in kind in OPSCAR.

10. The Board also stresses cooperation among Centers - there I find it hard to believe that they can fault ICRISAT in Africa, but perhaps we need to strengthen our cooperation from IC. One way to strengthen research both with NARS and other IARCs at the same time and to answer the questionss about reinvesting in Vertisol research would be to build a 5 year-long special project for Applied/Adaptive research on the Vertisols in Ethiopia.

11. One recent review of Sahelian agriculture said low research conservation model approaches to agricultural development focussing on labor intensive cropping systems using soil manure and few purchased inputs have proven incapable of reaching ... The predictability of the rainfall - has this been built into OPSCAR? Has its implications been considered to all the other yield increasing factors ...

    You should be aware that IITA after very intensive discussions of its strategic plans over years has decided to stress in its future research modified low input systems stressing use of resistant cultivars and biological control in Phase I, then fallow management, alley farming and crop management in Phase II, and fertilizer responsive cultivars, agricultural chemicals and mechanization only in Phase III. Presumably the phases represent some sort of time dimension.

12. Changing the mandate: No cotton, no other legumes or oilseeds, probably finger millet. Suggested change is the greater emphasis that needs to be given to future feed and forage uses of our mandate crops, particularly in Africa or indirectly in Asia. We need to monitor everywhere the growing demand for feed grains and forages, and specifically for feeds and forages from sorghum, millet, groundnut, and soybeans.

Now I wish to make a plea for your assistance. It concerns sustainability. As most of you know, I am chairman of the CG Sustainability Committee. The initial report of the Committee was well received by the CG. In two weeks time the Committee will meet to consider its next steps. They are:

1. Exploring areas for cooperation amongst the IARCs in sustainability research.

2. Involving NARS and Universities.

3. Filling some of the identified gaps by utilizing existing sources of funding including the additional issues we should receive during the current MTP.

4. Filling the gaps with additional sources of funds. The major gaps are: (a) Measurement and long term studies of

sustainability, (b) Sustainability of emerging farming systems, (c) Farmer perceptions and responses, (d) Rehabilitation of degraded lands, and (e) Trees in farming systems. Agroforestry. Only the latter one - Agroforestry - is currently a strong candidate for additional funds. We should decide whether we wish to go after them or not. What I ask is that at sometime during these sessions - perhaps in a special evening session a group of you decide upon a positive set of ICRISAT responses to the above issues. ICRISAT can and should show some leadership in this major new thrust for the CGIAR.

Let me repeat in case my remarks have sounded overly critical that I am impressed by what is said in the two chapters of the Strategic Plan that relate particularly to RMP. They provide a sound basis for your forthcoming discussions.

Bon Chance!

Dr. J.L. Monteith: Structure and Objectives of Review

Good morning Mr. Chairman, Dr. Swindale, colleagues from In-House and friends from a variety of out-houses!

Although it is less than 3 years since I joined the staff of ICRISAT, this is the third review of the Resource Management Program I have attended because, a few months before I came to ICRISAT, Dr. Swindale kindly invited me to attend the first review of the Program in May 1986. At that time, I was impressed by the very wide range of work going on within the Program; but it was difficult for me, as a newcomer, to see how the large number of projects, fitted together in the end of the day.

When we sat down little more than a year later to organise the next review, we tried to find a structure for it. You may remember the organogram that we devised where we had themes like "assessment of resources", "sustainability" and so on. That organogram enabled us to see more clearly the links that exist between different parts of the Program's activities. We still tackled the discussion of what we had done or intended to do in terms of projects so it was sometimes still difficult to see the wood from the individual project trees.

This third review is of a very different kind because, as Dr. Swindale has already pointed, it is an integral part of the exercise of devising a strategic plan for the Institute's next decade. So it is concerned with the goals that lie ahead of us rather than with the successes and achievements behind us, though one is naturally built on the other. It is concerned with broad ideas and concepts rather than technical details. It is concerned with making changes rather than trying to preserve the status quo. It is concerned with discussing rather than just listening. We have tried to organise the program so that at least half of each session will be available for discussion. We have appointed rapporteurs so that these discussions can be written down, organized and eventually brought together in a report. Finally, it is concerned with an attitude to research which can be described as extrovert rather than introvert.

May I take a minute to elucidate what I mean by that last statement, using architectural analogs? When Building 303 was constructed, there were many principal staff and national scientists in the Farming Systems Program and a large number of offices were provided for them in a relatively small space, so that we ended up with a lot of boxes. That was desirable for personal privacy perhaps, but it discouraged the exchange of views, ideas and discussions between groups that are essential in any Farming Systems Program. The problem was exaggerated by the fact that there were no convenient common-room facilities associated with 303.

Those of you who work in the Program are aware that moves to overcome these problems have already begun. In the first

instance, the wall that used to divide Cropping Systems from Production Agronomy has been taken down-and that is symbolic! I hope it will lead to an efficient share in facilities and fruitful sharing of ideas as well. Then for many years we have had to use the 303 seminar room as a common room, again with several symbolic disadvantages. One was the noise created by the air-conditioning system which made it very difficult to hear what our colleagues were saying to each other. The second was that because the windows were high and curtained, it was impossible for us to connect visually with the outside world. Above this conference hall, there is a room which is quiet and bright and where the outside world is clearly visible. We hope that when this becomes our new seminar room, it will be the site of many fruitful discussions both within the Program and with our colleagues in other parts of the Institute. That is what I mean by extrovert: being turned outwards to welcome these colleagues into our new quarters and to be aware of what is going on in the outside world.

Symbolically again, I arranged this morning that some of the curtains in this hall should be pulled back because for many years I have sat here and felt somewhat oppressed by being completely cut off from the external environment. So I came in early this morning and opened a few curtains. When I came half-an-hour later they were closed again! I also discovered that the curtains behind the screen cannot be opened; they are permanently fixed. I think we must be aware of this kind of attitude in our minds because if we spend too long in our offices and working within ICRISAT Center then we may find permanently fixed curtains within our minds.

Talking about buildings reminds me that our RMP colleagues in the West African Center were fortunate to move very recently into splendid new buildings with laboratories and offices purpose-built for the work that they do. We congratulate them on reaching this important stage in their development and hope that they will continue to expand the excellent work which they have already started.

I talked about the need for being extrovert primarily in terms of the Institute but we are also extremely conscious of the need to strengthen our links with outside bodies and particularly with the National Agricultural Research Services. We are delighted that both Dr. Abrol and Dr. R.P. Singh were able to accept our invitation to attend this review and to take an active part in it.

I turn now to the structure of the review. Some weeks ago, those of us concerned with the environmental report which Dr. Swindale has already referred to, decided that we should try to formulate some kind of a mission statement for environmental research with the Institute. We made various attempts which we were not very happy with and in the end of the day, Tom Walker took a look at it and said "you can't do better than the mandate". He was right. Part of the mandate reads:

- Develop improved farming systems that will help to increase and stabilize agricultural production through more effective use of natural and human resources in the seasonally dry semi-arid tropics;

- Identify constraints to agricultural development in the semi-arid tropics and evaluate means of alleviating them through technological and institutional changes.

These sections of the mandate relate specifically to the work of the Resource Management Program and are so important to us that we should perhaps stand up and recite them together at the beginning of every RMP review. In strategic terms, our goal is to improve farming systems by efficient use of natural and human resources. We can do that by identifying constraints and then evaluating the means that we develop to alleviate them. So the mandate give us a very sound starting point for strategic planning.

In our previous Program reviews it has been difficult to relate the mandate to a multiplicity of projects because there was a gap between them. What we found difficult to do, as I have suggested already, was to see the mandate wood for the project trees. At our last In-House Review we did try to arrange projects to form a mandate wood.

What we are doing now is something rather different although, as you will see in a moment, it does bring back projects in the end of the day. We start again with our mandate. From the mandate we pick out a number of key ideas. First of all, "resources" that are available to us, then "improved farming systems", then the "constraints" that we need to overcome in order to achieve that improvement, and the "evaluation" of the means that we try to put into place. If you look in your blue books, you will find these are the four major themes of this review. We call them "themes" to distinguish them from the other subdivisions of the mandate. So, very closely tied to the mandate through the words underlined, are the four major themes that will occupy us for the next three days.

We have subdivided the themes into a number of thrusts and session by session we will discuss our goals for each of these thrusts. When we sat round the table to look at the thrusts, we felt we needed subdivisions. The thrusts were still too large to be able to identify individual scientific components. So we now have components as well. You will find at the back of your book (p. 41) a list of our thrusts and in some instances the thrusts are divided into components. Please don't take this as the final definite statements of the Program, because these statements will be revised in the light of our discussions. They are preliminary and in some cases, the way in which the material has been divided by different groups is not entirely consistent: some of the components are smaller than others.

If you look at the components, you will find that you are getting fairly close to the dimensions of projects. I don't think it would be difficult for us after this review is over (and when we come to the next exercise which Dr. Nene has asked us to look at very shortly to revise the projects. At the end of the day we shall have themes and thrusts linking mandate to projects. This is different from what we tried not entirely successfully to do earlier--to bring the projects together and then try and see how they formed our mandate wood. This time I think we got it the right way round. Looking to the future and basing our whole program on the principles that were established by the far-sighted people who set up ICRISAT, I think we can divide our work in a way that takes us from the mandate down to the project level. That is the kind of exercise that might possibly be looked at in other Programs as well, so that it becomes an institute-wide contribution to the Strategic Plan.

In your blue books on page 41, there is a very important table showing links within the Program which has got a series of stars and hashes in it. The point about this table is that if you look at it as a vertical distribution of subjects, you see how it divides into Agronomy, Soil and Economics-our disciplinary and administrative groups. It takes account of contributions both from IC and from ISC in the two columns under these headings.

Dr. Swindale has already stressed that the whole point of forming a Resource Management Program is its the work should be truly interdisciplinary. You will see how that has been achieved by looking at horizontal entries in the table. In each theme and each thrust, we have started to form interdisciplinary links. I think most of us would accept that we still have quite a long way before we realise the full potential of interdisciplinary expertise within the Resource Management Program. So although the table is to some extent a statement of achievement, it is even more a statement of intent and of our strategy for the next 10 years or so.

I hope that those of you who contribute to the discussion of our thrusts and components of thrusts over the next few days will pick out and emphasise for us the extent to which lines of work are interdisciplinary both within the program itself; in the connections between the Resource Management Program and the Crop programs; and in connections with national agricultural research services in Asia and in Africa. Perhaps the motto of the Resource Management Program if not the whole of ICRISAT, should be taken from one of E.M. Forster's novels where the theme "only connect" is repeatedly stressed. We must connect in many different ways within the program and outside it.

So far I have talked mainly about the structure that has focussed our attention on a number of long-term strategic objectives. I now wish to say a word about these objectives and I shall do so in terms of a series of questions. We are certainly not going to answer all these questions within the next few days but I hope that the presentations are going to clarify our ideas

and that they will generate new ideas as we go along. We plan to have a series of later meetings within the program to consider unresolved questions in more detail.

First is the question that has already been raised by Dr. Swindale with regards to <u>where</u> RMP should operate. I hope that Dr. Walker is going to start to answer that question later on this morning when he talks about the regional demand for technology. There are clearly severe geographical constraints to what can be done by relatively small group of RMP scientists, even if IC and ISC combine forces. Behind the question "Where should we operate?" lies a more fundamental question: "Where are we most needed?" How should we decide needs: in terms of seasonal or chronic food shortages; in terms of population?

The next question brings us to constraints. How should we identify the major constraints that produce shortage of food? To what extent should we be talking to farmers? To what extent should we be involved in diagnostic research on yield gaps or collaborating with NARS? Nearer home, how much time should scientists be spending in the Library, a large and under-used resource within ICRISAT where much relevant work done in the past can help to guide our steps in the future.

Having decided where needs exists and what major constraints lie behind them, we should ask: is it feasible and desirable for Resource Management to become involved? We need to assess feasibility in terms of resources at our disposal, our scientific expertise, our technical skill, our capability in terms of logistics, our financial support, and so on.

I have reached my conclusion--and I hope my colleagues will realize that I have managed not to mention either models or fundamental processes! I wanted to finish by saying that just as the strategic planning exercises come at a very opportune time in the history of the Institute, this Review, as Dr. Swindale has already said, has come at the right moment in the relatively short life of the Resource Management Program. Since the Program was formed at the end of 1985, scientists from a wide range of disciplines have settled down together; they have learned far more about each other's work and each other's ways of thinking than I believe they would have done if they had remained in separate sub-programs. They have established harmonious relations in some areas and in others they have developed "creative tensions". I stress again that so far we have talked about collaboration and connections more than we have actually collaborated or connected within our Program, with our colleagues in the crop programs and with our colleagues outside in the NARSs. My hope for this review Mr. Chairman, is that in helping us to plan our way forward, it will encourage us to make these connections. And that the way we connect ideas and people and projects, will in the end of the day serve as a model for the many Institutions which share our concern for the welfare of farming households in the tropics and particularly in the semi-arid tropics. Thank you.

T.S. Walker: Regional demand for Technology

I am glad to see that the DG is still with us, so we can discuss the areas of creative tension. There are not that many. I also welcome everyone from outside of ICRISAT. The rationale for this presentation probably is not immediately obvious from the program, but basically when we thought about organising this global in-house review, we listed about 10 major questions and issues. The idea at that time was to organize the review around those ten questions. Then we decided more for a substantive area thrust format and most of these questions were covered. However, there is one major question that we continue to thrash around and that is whether or not we should be working on environment of high or low production potential and/or high or low rainfall. Also, there is the question of what types of technology should we be working on in those different environments? These questions have not been considered. That is the motivation for this talk. What I am going to talk about will become apparent but first of all, let me tell you what I am not going to talk about. I am not going to talk about commodity production, price policy or trends in foodgrain availability, desirability which the DG referred to, or even need. When one thinks of demand, one conjures up images of those items. I am not not even going to talk about Vertisols, Alfisols, Entisols or any kind of sols for that matter, although indirectly some of the implications of the talk will flow on to those different soil goups. What I am going to focus on are the prospects for adoption of different types of technology in different agroclimatic environments and particularly how those prospects are influenced by the development or evolution of farming systems over space and time. It is very appropriate that we have the chairman Dr. deWet today so he can correct any points with regard to plant evolution and evolution in general.

The talk draws heavily on previous work of ICRISAT economists, most notably Hans Binswanger, Peter Matlon and John McIntire. The focus is on West Africa and India's semi-arid tropics. (On Friday, we discussed Antarctica and so I am not going to cover that terrain again). Also, in terms of fast breaking events, I am not going to refer to the southern part of the Soviet Union which could become important perhaps and would reinforce our mandate in chickpea. The focus will be on India and the semi-arid tropics. I approach this very comprehensive subject with a great deal of humility although a lot of you will find that very difficult to believe and after this talk you will probably become convinced that my main form of exercise is to jump to conclusions. (That is what Ron Gibbons told me the other day when I asked him what he does for exercise).

As a heuristic device I always go back to a paper that Binswanger, Kampen and Krantz wrote in 1976 that looks at prospects for adoption and feasibility. We can think of this as a space for experimentation. Within the space of all the possible types of experiments one could experiment on, there is a set 'S' for soils which are important and have some relevance to farmers'

circumstances. There is an another set 'C' for crops or for Agronomy and there is another set for Economics and basically at the intersection of these three sets, we have something, not completely but partially, which the farmer should be able to adopt and which is relevant to farmer's circumstances. Essentially, what we have to do is get ourselves within each of these 3 sets and try to get as soon as possible into the intersection. Now basically what I am going to be talking today is what is the size of this economic set? What is the boundary determined by? There are certain places in this world where this economic set is very large (eg. one would be for example the postrainy season sorghum growing environment in India.) We have relatively well integrated markets, we have good infrastructure and we have a decent amount of human capital, although skills are lacking, and what is small in that particular environment would be that the climatic set and the soil set would be very tiny, representing the difficulty of producing under a receding moisture regime. There are other cases where the climatic and soils sets would be very large in terms of sparsely populated areas of good production potential reasons which may not be inhabited for reasons of diseases of pests but where the economic set reduces down to a point and effectively is a null set. One can think of shifting cultivation, or swidden agriculture, and burn agriculture; one can also think of pastoralism where agricultural research essentially has a little leverage over the lives of the people in those environments because this set, i.e., these economic boundaries and constraints are so sharp and well defined. ILCA in their strategic plan, finally bit the bullet and said that they were not going to invest more research in pastoralism amongst their thrust areas. Curt Farrar who was a member of our first reactor panel to our Strategic Plan said that the donors took it bad but they took it. I think we have some areas like that in the semi-arid tropics but fortunately for us they are very sparsely populated and not a lot of people live in them at this point in time. Now, in order to place this into a perspective and this perhaps goes back to what Dr. Swindale mentioned that there are problems of infrastructure, and policy in West Africa. These are some illustrative data from Burkina Faso that Peter Matlon has pulled together. We know for a fact that if you put enough labor and enough capital, both monetary capital and human capital on a piece of land you can usually get higher yields. For example, if we have a good cultivar, we do ploughing, we have a good fertilizer recommendation, with tied ridges, we should be able to get 1.5 to 3 tons fairly easily, either on station or even in some cases on farm. So we know this is technologically feasible but the question is, does the investment of the capital and the labor pay? How do we look at that investment to see whether or not it does pay? The way I am going to do it is to look at the evolution of farming systems over space and time. We start with hunting and gathering societies, and these were very land extensive, very low population levels and they were also very sustainable and lasted for about 4 and half million years. We had the transition to agriculture that started 10,000 years before the present and it was fairly rapid. It only took 8000

years to complete--fairly rapid compared to the earlier 4000 years. This transition was accompanied by very sharp rise in population density. Relatively speaking, it was a much sharper increase in population than what we experienced today with the demographic transition in the developing countries. Now, as an aside here and this is strictly an aside, there are several hypotheses for the transition. Social scientists are not sure which of these hypothesis is true. It could be either technological innovation, population density itself, or an environmental hypothesis. The environmental hypothesis if it is true is interesting. The environmental hypothesis essentially says, that in the Pleiocene era man over hunted large animals to the point of extinction. If man at that point in time had been able to recognize that large mammals were common property resource, then many of us today will still be a gleen in our ancestoral lives or we will still be living in a hunting and gathering society which is rather boring and probably would not be very pleasing propspect for the vegetarians amongst us either. The message is: sometimes, sustainability may not be a good thing; sometimes it is good to be unsustainable also. Now lets move on to the thrust of the presentation.

I think most of us have seen this by now in terms of evolution of farming systems from Ruthenberg's work, from Ester Boserup's work and from others that as population density increases, then once we have established agriculture, we go from a forest fallow to bush fallow, to short fallow, annual cultivation for multiple cropping and what happens then is that infrastructure increases and we come to a stage where we have well developed and articulated land, labor, capital and output markets. We essentially go from a state in forest fallow where the opportunity cost of the land is zero, land is abundant and there is no market for land. Gradually as population density increases, property rights become institutionalised, the same way with the labor market and depending on development policies, labor can eventually become either dear or cheap.

Initially, the capital markets are very scarce and then rural financial markets gradually develop there is a term that economists use called finance intermediation which means a lot of borrowing and lending take place. Transactions are very impersonal and capital becomes cheaper relative to land. Over a long span of time we go from a very subsistence agriculture to an agriculture which is specialized and commercialized where marketed surplus increases. Now let us look at some data to show the level of the market development in the early 1980s in some of the study villages. I use the Burkina Faso data for West Africa and our own Indian data. There are a couple of surprises in this data set and there is a lot of reinforcement of conventional wisdom also, for example, the proportion of hired labor to crop labor in the Sahel is only 0.04, i.e. (96%) of total labor in crop production is supplied by the farm household. With cotton production in the north Guinean zone, it increases a bit with cash crops. In India hired laborers' share to total labor is somewhere between 1/3 to 2/3 with fairly developed labor

markets and ways to cope with seasonality in labor demand. Now what is interesting here, (I always knew that weeding was extremely important in West Africa), but in the Sahel 70% of crop labor use goes on weeding. It is a tremendous constraint, not only in terms of seasonally but it also has some implications that are somewhat more subtle. First, farmers in the Sahel really cannot take much advantage of a good production year because they are going to plant more land than they can weed and they will not be able to make full benefits of those good production years. Also recommendations on planting date from the most part are irrelevant because what the farmer has to do is to spread this labor demand at weeding; he has to plant whenever it rains so that you get this demand being spread. In India, where animal traction is well developed, only about 10 to 30% of labor goes towards weeding. In these households in these African villages about 15% had access to animal traction in each of these villages in Burkina Faso. But what you see is that it takes about 7 to eight years to reap the benefits to animal traction as a technology. In India, obviously animal traction is well established. Taking the proportion of the cash expenses to total cost, you also find very large differences as expected and in India more than 50% in these poor semi-arid tropical villages of total outlay comes through out-of-pocket expenses, whereas in West Africa we are down at a very low rate even though there is a considerable amount of exchange in buying and selling particularly in these zones for food consumption. If we go to the last item in terms of markets; (unfortunately, I do not have any price data for West Africa) but in India, over the last few years, if you chart in these three representative villages that we have from 1975 to 1984 when these studies were terminated, we see that for cereal prices in the open market, (note that these are not government support prices) the mean average prices that farmers sell their produce are very flat. There is almost no price risk. In fact when we run experiments in these villages farmers can predict (on average, 90% of the time) they can predict their price within 15 to 20%, and most times, they can predict, for example, their paddy price within 10%. So there is limited price risk. That is because the size of the economy is large and it is fairly well integrated; I don't think you will find that if you charted prices in West African villages, (even though these were not years of a marked drought) you would not find a cv of prices which would be nearly as small as what you see here.

Now let's look at some other considerations in this picture. Essentially, if we are talking about land abundance then, and criterion for adoption-a criterion that cuts across all technologies, all types of resource endowments, or climatic environments-is to reduce the unit cost of production. If we have a yield increase in technology, what does that mean? That means under conditions of land scarcity, such as we have in Asia, it implies a savings in land and that's the value to that technology. For land abundance, it implies savings in labor. If we have a technology like fertilizer it means how much more labor does the farmer have to spend to weed better, to get a fertilizer

response and compare that yield then with the yield that he will get from planting more land, because the land frontier is not yet closed. What we find in this transition, for example, is in general, leapfrogging is difficult; that is, it is very hard to go from bush fallow into annual cultivation or multiple cropping; to go from hand hoe agriculture to tractorization, or to go from pastoralism back to specialization in livestock again. Because there is a gradual progression and that progression is essentially dictated by economics and destumping, and infrastructure, and it is very difficult to short-circuit this process. The only way the process, I think can be short-circuited historically, is through export markets. If there is a strong export market then everything that I have said in the other diagram is irrelevant. I think particularly, during the colonial era in Africa, a lot of the research by small teams on export commodities shows that agricultural research can pay if there is a strong export market even under conditions of land abundance.

Now there is a silver lining in all this. With population growth in the semi-arid tropics which is projected to increase at 3.2% in sub-Sahelian Africa, the conditions for yield increasing biological and chemical changes are better now than they had been in the past. That is, for the most part this circle is gradually expanding. We are much better placed with our main area mandate environment of the SAT than is either IITA of the humid tropics or subtropics or ICARDA in the arid regions of the world. This environment can be regarded as an opportunity.

In the process of agricultural intensification, is there any congruence between areas where the population growth is rising and areas of good production potential? What we mainly find from African studies is that this varies from country to country. There seems to be reasonably good congruence in Kenya and Malawi, very poor congruence in Burkina Faso and perhaps Senegal and Nigeria. We also know that we cannot rely on migration to good production environments to solve this problem because most colonization programs anywhere in the world have a very poor track record. They almost always never worked. Because of a lack of congruence and because migration, at least the immediate to short-term or future is not going to solve the problem, we need to stay in the areas of higher population growth even in relatively poor production potential environments and that increases the demand for land conserving technology.

Let's go to specifics now, with regard to West Africa. This is also taken from Peter Matlon's paper which divided the region up into four zones: the Sahel with less than 300 mm rainfall, the Sahelian-Sudanian zone with 350-600 mm rainfall, the Sudanian zone with 600-800 mm etc., and if you look at the population density (persons per km^2), these levels of population density are what one finds now in western and central Rajasthan. That's the levels we are talking about in order to place them in some perspective. We can also see here that in general there is not much congruence between where population is growing and

relatively dense and production potential, for example in Sudanian-Guinean's zone which has perhaps the highest production potential in terms of rainfall and soils, it is still relatively uninhabited compared to the Sahelian-Sudanian and the Sudanian zones. There seems to be a lack of congruence there.

The different technologies:

We have four different types of technologies. We have high-input yield increasing, stress avoiding or stress tolerant, labor saving and land conserving. I have marked with checks here, where I think there is a demand into the future to the year 2000 for these different technologies. Irrigation under conditions of land abundance does not work and we know that not only from Africa but also from Asia that is why until the closing of the frontier in Thailand there has been relatively little demand for irrigation. If we have areas (intramarginal areas) of land scarcity, we should see some minor irrigation coming in. The problem with that is as Matlon says is in those places where there is a little bit of small-scale, minor irrigation the areas will be reserved for vegetables and for higher value cash crops, which are not ICRISAT's mandate crops. The question, I guess is; is it very likely that these crops will find a home in those areas. To some extent, they have partially done so in India. Fertilizer availability should increase as subsidy policies decline; that should free up foreign exchange to buy more fertilizers but for all practical purposes given the experience ir India, the fertilizer if it is scarce, is going to go to the zone that has the highest profitability to apply fertilizer which in this case will be the zone with the longest growing season where most water is available for the fertilizer interaction which should be in Sudanian-Guinean zone. Input responsive cultivars have pretty much the same story. Here in the good production potential environment we need input responses to be able to compete with maize and other crops. If we don't have it, we are not going to be able to compete. Tied ridges is given by Peter Matlon as an example of yield increasing labor intensive cultural practice and as we know tied ridges do not technically work in the Sahelian because it is too dry. In the Sudanian-Guinean zone it is too wet. We have two cases: (i) areas where there already is a high population pressure, so there should be some demand for tied ridging and we have already seen some field experience of tied ridging in those areas. That will be mainly on small plots and again would perhaps be on water responsive crops such as maize; (ii) in more sparsely populated areas, there is a demand for animal drawn equipment to make tieds and there is a large demand there. Particularly in areas of higher population density low and where land is rapidly degrading, there should be a large demand for technology such as tied ridging, and in situ moisture conservation.

Stress avoiding technologies

What we are talking about here are nickels and dimes that probably are not going to show up in production statistics but they are going to be adopted by farmers. The fact that they are adopted by farmers eg. stress tolerance varieties, means that the agricultural research establishment has done a good job. In the Sahel we know nature is niggardly and we have to take what nature gives. There are a number of cases of diffusion of stress avoiding cultivars in the Matlon paper, and we see farmers changing their own cultivars in these different areas. Stress avoiding or stress tolerant technologies are not going to be relevant to the Sudano-Guinean zone, I think because of production potential. There you really need the yield potential and if you take any decrease in yield potential to incorporate the stress or the tolerance, from our experience here, from CIMMYT's experience in Pakistan, farmers simply are not going to be interested. They want that high yield potential.

Herbicides

Even though there is tremendous amount of labor spent on weeding, with the closing of land frontier over time with population density and with the rapid increase in the rural work force herbicide is not going to pay. The work force is projected to increase at a rate somewhere around 2.5 to 2 per cent. In order to keep the work force constant in agriculture, a rate of out-migration to towns and cities of 6 to 7% would be required. Historically, Africa has a high rate of out-migration but we think that the price of labor relative to land is going to stay relatively low into the indefinite future.

Animal traction

Animal traction is again feasible in areas of grass fallow where destumping has already occurred, that means areas probably of higher population density and where you have a longer growing season so that you can get greater utilization out of the animals. Again, animal traction would seem to have demands strongest in the Sudanian and the Sudanian-Guinean zone. Land conserving technology (eg. rock bunding, earthen bunding) seem to be most applicable in the Sahelian-Sudanian and Sudanian zones where the land is fast degrading and where there is a need to invest labor to improve that resource base. The advantage of these technologies is that you can invest the labor in the off-season. Most of these works as Matlon says have been done by NGOs. To my knowledge, there has not been a great deal of research on these technologies yet. This is one area where there should be demand for technologies in conserving land.

Let's go to India and I just want to make one point with regard to India. The really critical question is, given the fact that in most representative rainfed agricultural regions, we have

some irrigation potential, which in this case will be 10 to 20% of gross cropped areas, how well does this rainfed agriculture compete with irrigation? In some cases, such as Mahbubnagar which has shallow soils with a very poorly distributed low rainfall, or Sholapur with poorly distributed rainfall, or in Sabarkanta where we have good rainfall, about 800 mm but sometimes very poorly distributed on sandy soils, rainfed agriculture simply does not compete with irrigated agriculture and is not going to compete with irrigated agriculture into the future. As India becomes more specialized over time in areas of comparative advantage, we are going to see some areas such as the Akola region with homogeneous, uniform, good soils where rainfed agriculture can hold on its own against irrigated agriculture.

Now we can see this by looking at these ratios. Some of this is location-specific, for example, in Mahbubnagar on these irrigated plots per unit of land, they employ 13 times more hired labor than they generally do on the rainfed plots. That is an indication that it is not going to compete. In these other regions we are talking about spending in terms of total resources 4 to 7 times as much on the irrigated plots as on the rainfed plots. In contrast, in this region (Akola) which has had a lot of growth in production since the early 60s and technical change in rainfed agriculture equivalent to a 5% growth rate, it is still a very poor region. It would still be very desirable to have productivity change there because it is not at all irrigated. This ratio falls to somewhere between 2 and 3. The other way to look at that would be to see what is the returns of rupees per ha by region. What we see in that good region of production potential, is that the returns per hectare of dryland cropping are about double what they are in the other regions, and that really is what drives the technical change in this region because we have competitive dryland crop production. Another way to look at this issue would be: how much labor does irrigation absorb with an increase in irrigation? This is another indication of these regional differences. Here we have an elasticity, which I am sure all of you are familiar with now, and this means that if we get a 10% change in irrigation we are going to use 4.8% more labor in this region. Why is that? That's because our rainfed agriculture is so labor extensive. In Akola and other regions, rainfed agriculture competes with the irrigated agriculture, has a longer growing season, better soils and irrigation does not absorb much labor. So, this is the region where the demand for labor has actually increased; and there are several regions like this in peninsular India where the demand for labor has actually increased over time in rainfed agriculture.

If you look over time in these villages with fairly active tenancy markets, there are three sets of farmers. There are farmers that on average leased-out some of their land or share-crop out some of their land, there are farmers who do not lease-in or do not share-crop out some of their land, and there are other farmers who lease-in land. We can see the strategies that farmers employ by examining land productivity of those who lease-

out. In general, at least in 2 of the 3 regions, the land productivity of the people who lease-out their land is greater than the other two groups. They focus all their resources on irrigation and let the dryland go. The dryland in these regions is going to degrade and there is nothing that we can do about it. In Akola, those who lease-in the land are actually the better farm managers and the ones that lease-out land have lower productivity, mainly because they are not committed to farming and because of personal vice such as alcohol, ganja smoking or whatever it may be. But this indicates differences in farmers' strategy; what the farmers are thinking about in these different regions. Here the more productive farmers, the ones that are leasing-in land, they are leasing their rainfed land and they are having higher crop productivity than others. In other words, the leasing behavior is a marker of farm management skill, which, in turn, is an indication or reflection of potential for adoption between irrigated and rainfed agriculture.

Now let us have a similar maping of what we had in West Africa. First in these regions like Akola, the sky is the limit. We have high yielding, input intensive agriculture and everything is normal in terms of agricultural research. The stress avoiding technologies are not going to work in that area because we need to keep high yield potential. There are only a few points that I want to make in this table. One is land conserving technologies are not going to work and there is going to be limited demand for them in areas which have ample scope for irrigation through intensification. The labor saving technologies are contingent upon the length of the growing season and on the amount of irrigation. So you get a spillover effect of tractorization from irrigation onto dryland agriculture.

Green manuring

These are techniques that generally will receive low marks on adoptibility. These are the areas of creative tension. Green manuring generally looms larger in the agronomist's mind than the farmer's. With increasing land scarcity, it is hard to see how there is going to be much demand for green manuring. It depends also upon fertilizer availability. If fertilizer availability is good obviously the demand for green manuring is going to decrease and it depends on the length of the growing season. An IRRI team has looked at green manuring in the rice based cropping systems and come to the conclusion that the scope is best in lowland rainfed rice where the length of the growing season is about 9 months, where you are constrained to get either one or two crops and you cannot get the second or the third crop, then you put in a green manure crop. But the length of the crop growing is such in our environments that, I think for all practicable purposes, green manuring is out.

Crop residues management

This is the area where we really part company; crop residue management. I guess it relates back to the fact that in rainfed agriculture I know no cases where farmers have ever (and this is a very categorical statement and I am sure it will be corrected in the discussion) incorporated residues to increase their production, particularly in our semi-arid areas. You can find some of it going on perhaps in some highland areas but not in the lowland semi-arid tropics. The main problems are (i) alternative uses, and (ii) grazing rights. You think the stuff is free but actually there are rights to herders.

Now if we are not talking about the incorporation, then the labor costs goes out. I think it behooves us to figure out if we do get a good technical response to crop residues to find out what is causing that response because that may give us clues to other things. I think it is also interesting to see how crop residues are used because as you go through that transition, you go to a state of crop-livestock in pastoralism, then transhumance and then into animal draft in mixed farming where crop residues are intensively used and then you go back to a state of specialization again where natural pasture and improved pasture and even forages come in. It seems as though crop residues being used to directly increase crop production never find their way into any of those stages. They are always dominated by some other activity.

Herbicides

Herbicides depend on the amount of labor saved and we forecast that wage rate trends (although real wages are increasing somewhat) are still going to be quite low. The labor saving you get in rainfed agriculture in India is not that great and we would expect that you will see the use of herbicides becoming more attractive in irrigated agriculture, particularly in the Punjab. There should be some spillover but I don't think by the year 2000, we are going to find that there is still large demand for herbicides in dryland agriculture. You may be able to see in areas where herbicides are used crops such as chillies which are planted in the middle of the rainy season. Or, we could save on the transplanting and go to direct seeding, something like that with herbicides is similar to what you see in paddy where you can save a tremendous amount of labor through the use of the herbicides because you can go to direct seeding.

Another set of techniques point us into areas and regions where the growing seasons is longer, and I do not think some of this has been appreciated as much as it could be. For example rotations, the problem with rotations when we look at our village level studies data, is most farmers see the need for rotation and they have an idealized rotation in their minds but because of area variability, that is, information on rainfall at the start of the rainy season, then when you incorporate that

information into decision, they change crops and so it is very difficult for them in the areas where there is a lot of rainfall uncertainty at planting to follow a rotation. You need areas which have a longer growing season and which have rainfall certainty at planting and those two areas may be correlated and in those areas you are also going to have more crop diversity.

Contingency cropping

We have done studies which have shown that in the production process in terms of sequential decision making, the value of information and what happens during the growing season is closely correlated or strongly linked to the length of the growing season. That is, if your growing season is extremely short there is going to be relatively little scope for contingency cropping and if it is longer then we have much more scope and it becomes much more valuable. Ideally, what you would want for contingency cropping would be an average of a long growing season and a lot of rainfall uncertainty at planting; that's where the value of contingency cropping would be greater.

Tractorization

If you look at the Indian data, we see the fastest growth in the regions of the initial adoption, i.e. over the last 10 to 15 years initial tractor stocks at the point of initial adoption determine the demand for tractors. We don't see much spillover in tractors into regions which are eminently rainfed and that's because it is very hard to get a rental market developed without access to irrigation which tends to link them to the length of the growing season. We also see over time throughout India particularly in the semi-arid tropics for rainfed agriculture; that every day there are fewer and fewer large farms available and we have to pay large amount in order to buy a tractor and then use it for hire or rent it for transport and so on. You see a few tractors in each of these villages but in future I do not think it will be all that sustainable. We have to stay for sometime with animal traction to the year 2000.

Summing up, regional demand in West Africa is still going to be related to stress avoiding, stress tolerant cultivars with acceptable postharvest and consumer characteristics. If we can marry the tolerance to good consumer characteristics then I think we have got a winner. As I said before, we are talking about nickels and dimes, that is what the environment allows us to reap from it at this point in time. We have under-invested perhaps in land conserving technologies in the areas of high population pressure and I think that could be an area for future investment. There is scope for introduction of new crops and new species in the Sahelian zone, particularly if it can reduce the unit cost of labor.

Agricultural intensification at the bottom of the

toposequence should also become more common. Initially, you start in the upper mid slope, then you focus on the mid-slope or the top of the toposequence and then you go down the slope to the heavier soils, where there is a demand for drainage. Most of the agricultural intensification will take place at the bottom of the toposequence. Mike Arnold, who was also a member of the first reactor panel raised the question: Who is doing the research and what is the demand for agricultural information to speed up that process? Who is doing that? I do not know if anyone is. I don't know if it is too location-specific work in that area. I think we need to recognize that this is where a lot of agricultural intensification is going to take place and that is where there is going to be a demand for technological change.

In India's semi-arid tropics, we need to work on the higher rainfed production potential environments, and that essentially means, central Maharashtra and central Madhya Pradesh; I think it means black soils and it means higher rainfall environments. It also means investing in drainage technologies. In those areas where the rainfed environment is not that well endowed but where there is irrigation, I think we could do some more work-Dr. Mueller feels strongly about this-on water response because occasionally our crops are going to find a home in those environments and they are going to yield more in those environments. I personally feel that that is the environment where short duration pigeonpea at this point in time has the best chance of finding a home. In India's SAT, if we work in the poor production environments, I think we need to marry those environment to well-defined cropping systems focus. I don't think we can just work on Vertic soils or droughty soils or this and that type of soil. We need to have a well defined cropping systems focus eg. either production under receding moisture with postrainy season sorghum or chickpea or perhaps pearl millet on sandy soils of Rajasthan.

The Approach

I think we need to rationalise our main station experimental research, we do too much of it. I recognize there are some types of research that you could only do here, we have a comparative advantage in certain types, particularly very labor measurement intensive research but we need to decentralise and invest more in travel. When I talk about decentralise, I do not mean we have to spread all over the place. We need to stay together. But we need to have more flexibility in the travel budget so that we can find out what is going on in the rest of the world. I guess at the next year's Annual Day, if the Management Committee decided to do a skit on Principal Staff and I was one of the characters, a person will get up and say synthesis three or four times, so this is not new. This is something which we still do not do well at all. Synthesize and review. One area where we can do this particularly is to systematically take inventory of the experience of project practitioners. What has worked in the field? What has not worked? Why has it not worked? Why has it

worked? I don't think we should be involved at all in development projects. We need to stay involved in research. We need to find out what is happening in development projects. We need to keep together, but we need a more synthetic and decentralised mode of operation. Thank you.

General discussion on Regional Demand for Technology

The discussion centered mainly on issues relating to priority environments to work on, crop diversity, length of the growing season, crop residues, and institutions.

- **Which regions?**

  There was a lengthy discussion on this issue but the house did not arrive at any definite conclusions. One school of thought was that we should examine the potential yield gap and select areas where rainfall is dependable and where RMP can make an impact. Others thought that for equity reasons, we should consider the marginal environments because the NARSs may not have the expertise to tackle such difficult and seemingly intractable problems associated with those environments.

- **Crop diversity**

  It was emphasized that there is an urgent need to have an integrated approach in order to examine both soil and crop related constraints because the choice of a cropping system will be based on both soil and climatic factors. Because this is an important issue, it was strongly felt that the research work of Agronomy and Soil Groups should be related and wherever possible these two groups should collaborate on projects. The question of whether to concentrate on stress avoidance or stress tolerance was raised and would need further consideration at later meetings of RMP. Generally, it was agreed that agronomists in West Africa need to use both stress tolerance and stress avoidance crops in their production systems because of the difficulties in predicting the probability of drought occurrence.

  It was pointed out that the main reason for lack of congruence between population density and production potential in some parts of West Africa as reported by Peter Matlon is the incidence of diseases in the north Guinean and Sudanian zones.

- **Crop residue**

  The issue of crop residues discussed by Dr. Walker in his presentation attracted many comments. Some of the comments are:

  (i) When farmers are provided with other options, it might be possible for them to release crop residues for soil improvement because they are aware that they need to manage their land. For example, if we know that a large proportion of crop residues is used by the farmer as fodder for his animals, we can direct research to provide alternatives for fodder or feed from say,

agroforestry systems so that crop residues from farms can be released for soil improvement.

(ii) Most of the soils in the Sahel are sandy, with very low levels of organic matter, low activity and low clay content. Therefore, crop residues play an important role in maintaining soil fertility and also in improving crop establishment in a region where wind erosion and sand blasting of emerging seedlings are major problems of stand establishment.

(iii) Even though we may observe yield increases when crop residues are incorporated, we need to keep in mind the long-term effects particularly, in relation to soil borne pathogens and insects. Hence, crop residue research should involve the entomologists and pathologists too.

- **Technology adoption**

It was noted that although land conservation technologies do exist in West Africa, farmers do not adopt them. The reason for non-adoption of even the existing technologies are mainly due to lack of infrastructure, farmer's knowledge and poor extension facilities. However, the most disturbing aspect is the non-adoption of technologies by even those farmers who participate in technology testing. This needs to be investigated thoroughly.

It was also indicated that the long-term property rights, especially in West Africa, where land appears to be abundant, might strongly influence adoption of land and crop management technologies.

- **Institutional problem**

Some members expressed surprise that economists should be emphasizing economic returns of agricultural production in countries where the provision of basic food is insufficient. It is an institutional problem to feed the population. In the Sahel we need to produce food crops to feed the people and probably look to remunerative crops for higher economic returns. Therefore, instead of emphasizing only economic returns, self-sufficiency must be emphasized.

PART 2 :. DISCUSSION OF FUTURE RESEARCH THRUSTS

Session 1. Characterization and evaluation of resources.

The objective of this session was to identify research thrusts in characterization and evaluation of resources in Asia and Africa. Presentations were made by Drs. S.M. Virmani (for Asia) and M.V.K. Sivakumar (for Africa). In his presentation of future priority areas for Asia, Dr. S.M. Virmani indicated that the Agroclimatology Unit intends to continue revising data for crop growth models, and will collaborate with:

(i) Soil Group to study the interaction between soils and climates, and erosion;

(ii) Economics Group to undertake crop risk studies;

(iii) Mentor institutes to study climatic variability; and

(iv) NARSs to collect minimum data sets in field experiments for testing and application of crop models.

Future research thrusts outlined by Dr. M.V.K. Sivakumar were:

(i) Wind erosion studies which involve a coordinated research by soils, agroforestry and cropping system scientists, to quantify the physical processes and the impact of wind erosion;

(ii) Energy balance studies in the Sahel with the cooperation of the Institute of Hydrology (U.K.);

(iii) Cooperation with the NARSs in the Sahelian region on agroclimatic analysis and applications, and

(iv) Collaboration between ISC and IC on the use of GIS.

DISCUSSION

The main issues discussed in this session were:

- **Software**

  It was suggested that before undertaking any major activity on software development, available packages should first be evaluated. In some cases, it may be desirable to contract such activities to some specialized institutes. Local software development should be taken up only after other options have been exhausted.

- **GIS**

  Initially, a consultant should be hired to develop local

capability and facilities to implement the use of GIS. Some of the GIS related research could also be contracted to specialized institutes.

- **Collaboration between ISC and IC**

ISC and IC have used similar methods and approaches for simple climatic characterization and computation of water availability periods. In addition, IC is using crop growth simulation models for estimating potential productivity probabilities. ISC is not yet using this approach. Yield estimation using existing crop models based on row crops is not readily suitable to crop production based on planting in hills that is used in the Sahel. Thus, there is a need for modeling different processes associated with existing practices before using crop models in the Sahel. Existing data from the sorghum and millet network in West Africa will be useful for testing crop models.

- **Length of growing periods in thermal time**

It would be advantageous for Agroclimatologists and Crop Scientists to specify length of growing periods in terms of thermal time. This would provide a rational basis for crop environment zonation. Work on temperature responses was considered to be important.

- **Probabilities of mid-season drought**

It was stressed that in addition to existing work on predicting length of growing period based on onset of rains in the Sahel, probabilities of mid-season drought (as was experienced in the current year) should be examined. Soil and water management practices should be developed/identified to overcome drought effects.

- **Simulation of components of Farming Systems**

Although modeling whole-farming systems is complex and time consuming, we should develop capabilities to simulate responses of a set of components of farming systems in different environments. For example, we should use crop models to screen environments for agroecological potentials. The probabilities of success of growing a particular crop and associated agronomic practices in an environment should receive preliminary analysis and help reduce the work for agronomists.

Session 2: Measurement and Management of Constraints-I

Three papers were presented in this session. Dr. Burford spoke on "Soil Management Research in India"; Dr. M.C. Klaij presented a paper on "Physical Aspects of Soil Research in West Africa" and Dr. A. Bationo spoke on "Chemical Aspects of Soil Research in West Africa".

Soil Management Research in India

The goal of soil management research in India is to identify priorities for research within ecological units up to the year 2000. The main focus will be to develop predictive models for crop growth and yield as influenced by soil physical, chemical and biological factors. Because nearly half of the SAT is occupied by Alfisol and related soils, diagnosis of production constraints and management of those constraints will receive most attention. In Vertisols, postrainy season cropping in India and rainy season cropping in Ethiopia will be studied. Maintenance of soil fertility (physical, chemical and biological), effect of erosion on soil properties and productivity, water management and water recycling are other areas of research that will be undertaken.

Soil Research in West Africa (Physical)

In West Africa, soil management constraints like low fertility, low organic matter, poor structure are well documented but because of population pressure on land, soils are degrading due to water and wind erosion. To reverse this process, the effectiveness of various cropping systems and soil management options will be studied. Crop management options will include high density, relay rotations and strip cropping. These systems will not only produce more biomass but will also protect the soil surface for long periods. For the soil management options, crop residues will receive a major emphasis. The effectiveness of tied ridges, strip tillage, minimum tillage will also be studied at benchmark sites on long-term basis.

Soil Research in West Africa (Chemical)

The region has poor sandy soils with low organic matter and low Cation Exchange Capacity. Research will be conducted on benchmark soils and later on farmers' fields to evaluate indigenous sources of P; time and method of fertilizer use; quantify the nutrient losses and finally model the response of nutrient uptake by millet crop in different moisture regimes. The experiments will run for long periods in order to examine residual effects as well as the impact of fertilizer use on soil environment and productivity.

DISCUSSION

- The thrust on crop residue management was the main focus of discussion. Suggestions were made to modify the definition of crop residue to include organic household refuse, leaf litter from trees etc. because in the SAT, farmers use their crop residues to feed cattle and return household manure and left-over crop residues (after feeding the animals) to improve the soil. It was strongly suggested therefore that a study on residue management should include a study of the nutrient content of farmyard and household manures, and fundamental processes and mechanisms on crop residue eg. effect on soil temperature when applied on the surface. A more integrated approach is required. Studies on long-term effects of crop residue on pest and disease, biological organisms, and microclimatology as well as management problems such as weeding, soil and water losses, and crop yield should be investigated.

- Most of the work is presently concentrated in the Sahelo-Sudanian region (300-600 mm rainfall) of West Africa. It would be appropriate to start working in the Sudanian (600-800 mm) and the Sudano-Guinean regions (above 800 mm) of West Africa where there are good chances of increasing food production.

- Soil management strategy should include interactions between tillage, weeds, soil, animal traction, crop residue, water and nutrient, crop retention and crop production.

- Alfisols are more variable in properties and depth. Where should we research on Alfisols in India? It was suggested that we initially look at the benchmark Alfisols.

Session 3: Measurement and Management of Constraints-II

Four papers were presented in this session. Dr. K.L. Sahrawat spoke on Chemical Component of Soil Management, Dr. K.K. Lee on the Biological Component, Dr. K.B. Laryea on Soil Physical Management and Dr. D.F. Yule on Water Management.

PRESENTATION

Soil Chemistry

The research in the soil chemistry component was divided into two sections:

1. Diagnosis of Chemical Constraints

2. Nutrient Management

The Diagnosis of Constraints covered: Aeration related biochemical reactions, allelopathy, soil reaction, and nutrient disorders (toxicities, deficiencies, and imbalances)

The Nutrient Management covered: residual effect of legumes, behavior of 'P' in Vertisol and efficiency of 'N' fertilizer in shallow and sandy soils and organic matter turn-over in Alfisols and Vertisols.

Soil Biology

The work presented under soil biology component was divided into two sections:

(i) Strategies for nutrient cycling in plant-soil systems.

(ii) Effects of soil biota on soil aggregate stability.

Strategies for nutrient cycling covered understanding biological reactions (below ground) affecting nutrient uptake and partitioning. The study of soil biota covered identification of the processes of aggregate formation and stabilization by soil organisms.

Soil Physical Management

The work presented under soil physical management component was divided into three main areas:

1. Characterization of Alfisols and Vertic Inceptisols with respect to movement of water.

2. Quantification of causes of soil degradation and

quantification of physical processes involved in seedling establishment.

3. Development and evaluation of soil management systems for enhancing infiltration, storage and consumptive-use of water.

Water Management

The work presented under this component covered:

(i) understanding the processes concerning effect of surface management on soil water balance and on erosion.

(ii) utilizing this understanding to improve soil surface conditions and crop water availability.

DISCUSSION

The major areas discussed are:

- **Overlap of work and lack of interaction between Soil Group and other Groups**

  It was felt that there was too much overlap in research being conducted by the different Units. For example, the work on biological strategies for nutrient cycling proposed by Plant Nutrition Unit and the work on cycling elements in rotation experiments being conducted by Soil Chemistry Unit are strongly connected. Similarly, the work proposed by Soil Physics and Land and Water Engineering overlap greatly and should be integrated.

  Also there was concern about lack of interaction between the research work of Soil Group and Agronomy in particular and the Crop Improvement Programs in general. Presentations of thrusts, though impressive, were compartmentalized and limited to each Unit instead of cutting across the boundaries of respective disciplines in the program. It was agreed that efforts should be made to get a really good integrated program in which research on soil water and nutrients are conducted in relation to production and phenology.

- **Nutrient management**

  Nutrient supply through organic and inorganic sources should be considered together. Also, soil moisture interactions with nutrients including those from organic sources should be considered.

- **Sandy soils in Rajasthan**

  Because ICRISAT's strategic plan calls for emphasis on the millet growing areas in Rajasthan which has sandy soils, there was a suggestion that the chemistry, physics and biology of these soils would provide some leads in West Africa. This was countered by an argument that Rajasthan is mainly an arid zone and that our geographic mandate limits us to semi-arid areas. Also the chances of making an impact in that zone was considered to be small.

- **Collaboration on soil organic matter studies at ISC**

  It was suggested that the Soil Biology Unit should help with the work on soil organic matter, the quality of organic matter and the biology of soils at ISC.

- Soil compaction, particularly, in Alfisols particularly limits seedling emergence and crop growth. It was therefore suggested that the area of soil compaction in relation to above- and below-ground growth and the interrelationship of compaction with temperature and moisture in Alfisols should be included in the thrusts for Soil Physics.

- It was indicated that in addition to the effect of soil physical factors and processes on seedling establishment, soil fauna and flora including termites etc. have tremendous impact on seedling establishment. A multi-disciplinary research involving soil physicists, physiologists, plant pathologists and entomologists should be established to tackle the problem of seedling establishment.

Session 4. Measurement and Management of Constraints-III.

Three papers were presented in this session which considered thrusts on disease and pest management and the diagnosis of constraints. Drs. D.R. Butler and K.F. Nwanze briefly outlined their research plans for Disease and pest management. Dr. M.M. Anders presented research plans for diagnosis of constraints.

PRESENTATION

Disease management

A series of experiments to be conducted both in the field and in controlled environment chambers were proposed. The main objectives of these experiments would be to identify and quantify the relationships between microclimatic variables, particularly relative humidity and temperature, and diseases.

Diseases to be studied will be selected on the basis of their global importance. Fundamental studies will provide principles applicable to a wide range of environments and locations.

Studies in controlled environment will be designed to quantify relationships between microclimate, disease infection and development on the crop. Field studies will aim to (i) identify and understand critical processes in disease progress such as sporulation, dispersion, infection, etc. in a particular system in relation to weather conditions; (ii) test the relationships between microclimate and disease observed in controlled environment experiments; and (iii) assess constraints to crop productivity from disease.

The results from the study will be used to (a) develop crop management and disease control strategies in order to reduce disease risk in a range of environments; (b) evolve improved screening techniques; and (c) incorporate the effects of diseases and pests into crop models for estimating and predicting yield losses.

The following diseases would be considered in their order of priority:

(i) Groundnut: rust; leaf spots (ongoing project, duration 5 years);

(ii) Sorghum: grain mold (due to start in 1990)

(iii) Pearl millet: Downy mildew (will not start for several years)

Insect host-plant interaction

Interdisciplinary approach from board room to field experimentation will be adopted to assess regional constraints from pests of global importance.

Studies on insect infestation and build-up in relation to microclimate, particularly moisture in the air, and on plant parts, internal plant water relations, and physiological processes of the plant will be carried out.

The studies aim to (i) understand the reasons behind pest development; (ii) evolve crop management strategies; and (iii) identify economic thresholds. The results from the studies could be used to evolve breeding techniques, and plan appropriate cropping systems without upsetting the ecosystem.

DISCUSSION

- It was noted that a major gap exists because if one wants to know the loss of yield as a consequence of disease incidence or attack by pests one would need to have a knowledge about the effect of diseases and pests on the physiology, particularly on the reduction in leaf area and changes in photosynthesis per unit leaf area. It was therefore suggested that studies on disease and pest management should cover the effect of diseases and pests on the physiological aspects of crop yield.

The following needs were identified:

- to study the interactions of edaphic x climatic x crop diseases and pests factors.
- to identify threshold crop growth stages when a disease can result in a significant loss of yield.
- to hold a seminar to discuss all aspects, including microclimate, infection processes, genotype x disease and pest interactions and ecological implications.
- to study soil-plant-insect relationship for evolving better crop management practices.
- to collaborate with Economics Group to assess yield losses.

PRESENTATION

Diagnosis of constraints

A proposal to study village management of organic amendment was presented. The proposal covers survey and study of on-farm use of farmyard manure (FYM) at the village level in order to (1)

identify and quantify management constraints; (2) develop management strategies for more efficient use and (3) develop effective methodology to assess farmers' agronomic constraints.

Studies will be carried out in two phases. Phase I (1989-1992) will involve a survey and diagnosis at village level so as to identify the existing practices, their advantages, drawbacks, and agronomic and economic constraints to effective FYM use.

In Phase II (1992-1998), methods of overcoming the constraints and management strategies for enhanced FYM use efficiency at village level will be devleoped.

Interfacing of livestock and crops was considered essential for focusing on common resources that could contribute to efficient management and increased productivity in the SAT.

A second proposal on cereal seedling establishment will identify the constraints to seedling establishment and farmers' practices that either cause or enhance the constraints. This project aims at developing effective crop management strategies which will result in improved seedling establishment and thus increase crop productivity. Seedling establishment is perceived as a major production problem in the SAT and therefore needs to be studied in depth, particularly the effects of farmers' management practices.

DISCUSSION

- Although several studies of FYM use in crop production have been carried out, there is still the need for an integrated study to quantify village FYM management, agronomic, economic, chemical and biological constraints to efficient use of FYM at village level.

- Constraints to FYM use at farm level vary with location, for example in West Africa small quantities of FYM and field size are major constraints while in India the supply of FYM is a major constraint as the sources of FYM are changing with time. The priority given to FYM in the list of constraints was sought.

- In the past several studies on seedling establishment both at the Center and at the village level proved inconclusive on account of great variability at the village and field levels. Lack of appropriate methodology was considered a major reason for the poor understanding of the problem.

- It was agreed that a multidisciplinary approach involving crop physiologists, soil physicists and crop breeders was needed to investigate the problem of seedling establishment. Review of existing work and proper planning of the experiments on seedling establishment right from the beginning was considered essential.

Session 5. Improvement of Production Systems-I.

Dr. C. Renard presented research plans on cropping systems for diverse environments while Dr. C.K. Ong discussed research thrusts for rice based cropping systems and contingency cropping.

Cropping systems for diverse environments

The main objectives of this thrust are to

i) diversify cropping systems in relation to rainfall, length of the rainy season and soils;

ii) develop technology based on location, demography, traditions and availability of resources eg. OPSCAR which was started deliberately with low input technology.

Future priorities would be:

i) characterization of traditional cropping systems;

ii) development of improved cropping and production systems and testing with NARSs.

Rice based cropping systems

The objectives of this research thrust are to:

i) identify crops and cultivars suitable for intercropping and sequence cropping with rice;

ii) develop cultural management practices for good stand establishment.

Future priorities will cover:

i) evaluation of crops for tolerance to waterlogging.

ii) studies on seedling establishment and soil properties.

iii) testing of technology at different locations.

Contingency cropping

This thrust aims to:

i) evaluate the prospects of extra-early genotypes of ICRISAT mandate crops as contingency crops;

ii) assess potential productivity in different ecological niches using crop simulation models.

Two priority areas to be considered are to:

i) establish the potential impact and direct the breeding efforts on extra-early genotypes;

ii) provide more options to farmers in high risk environments.

DISCUSSION

- It was noted that rice-based cropping system is an important area of work because farmers in Asia have to diversify and change from the continuous rice cultivation which has been the feature of delta areas and irrigated rice systems in Asia for many years. It was suggested that we should request IRRI to provide soils expertise in rice-based cropping systems experiments and monitoring because of its long experience in this field.

- Because generalisation of results obtained at ICRISAT on contingency cropping to other years and other locations would require a very careful tie up with climatology, it was suggested that the Agroclimatology and Cropping Systems Units should develop more collaborative research in future.

- Crop rotations and intercropping experiments should include cereals and legumes for increased and sustained productivity.

- It was indicated that there is the possibility of using computer models to select what might be the best combination of cropping systems so that each year a farmer would plant a particular combination which on average over a number of years gives the most stable and largest yields. In this exercise one has to know very precisely the rainfall probabilities which will be part of the input for a model of this type.

Session 6. Improvement of Production Systems - II

Four research thrusts--two on agroforestry and two in testing of technologies were presented. Drs. C.K. Ong and Rick J.v.D. Beldt presented plans for perennial pigeonpea for agroforestry uses and agro-silvipastoral systems respectively. Drs. S.V.R. Shetty and M.M. Anders considered crop production components on production and pigeonpea production systems respectively.

AGROFORESTRY

Perennial pigeonpea for agroforestry uses

The objectives of this research thrust are to:

i) develop management practices for perennial pigeonpea;

ii) identify ecological niches for perennial pigeonpea and its consequences on soil properties.

Future research plans would:

i) stimulate NARS in the SAT region to adopt perennial pigeonpea technology to benefit small farmers;

ii) exploit the use of perennial pigeonpea as fodder;

iii) assess the adaptation of perennial pigeonpea outside traditional regions.

Agro-silvipastoral systems

The objectives of the thrust area on agro-silvipastoral systems are to:

i) determine the quality and supply of browse and fodder species and their economics;

ii) incorporate these species in crop/livestock systems.

Future research plans would consider:

i) adaptation of generated technology;

ii) increased production of forestry species at the farm level.

DISCUSSION

- It was indicated that as far as possible, indigenous tree species should be included in agroforestry technologies.

- Agroforestry is becoming synonymous with alley cropping but traditional agroforestry includes landscape considerations. In India, we must note the objectives and suggest species suitable for watershed programs and degraded lands.

TESTING TECHNOLOGIES

Effects of crop production components on production and economic sustainability

The objectives for this research thrust are to develop:

i) better management strategies.

ii) optimal use of ICRISAT technology.

iii) production system models and expert system programs.

Future plans include:

i) the identification of related production problems;

ii) evaluation of individual and combined technologies for wider adaptation in the SAT.

Pigeonpea production systems

This research thrust aims to:

i) develop strategies for varied rainfed production systems;

ii) identify constraints in cropping systems.

Future plans would center mainly on the management strategies to overcome constraints.

DISCUSSION

- Different components of production such as crop varieties, fertilizers, use of animal traction and implements should be included while developing a technology.

- NARS should be treated as partners and included in the project development right from the planting stage of experiments. Collaboration and testing of technology may not be fruitful if this principle is ignored.

Session 7. Assessment of Technology, Markets and Institutions.

Research thrust plans on Economic and Social analysis at the microlevel were presented by Drs. J. Baidu-Forson and T.S. Walker. The latter also presented thrust plans on National Resource Economics. Research thrust plans for Market and Policy analysis and Research on Research were presented by Drs. J. Baidu-Forson and R.A.E. Mueller.

Economic and Social Analysis at Micro Level

In this research thrust area, 7 components (3 in West Africa and 4 in India) of research were presented.

In West Africa the main components are:

1. Behavioral Studies which focus on implications of allocative patterns in farm households, pattern of management of agricultural environment, and effect of institutions on the household behavior.

2. Technology Assessment which includes on-farm tests, early acceptance studies and impact studies.

3. Resource Characterization which deals with appraisal of farm level resources, identification of constraints and problems, and revision of data base to examine socioeconomic changes.

In India, the components in this thrust area are:

1. Evaluation of Farming Systems in the SAT. This project will focus on historical and spatial regularity in the adoption of crop, land and water management practices. Other IARCs, and NARS may be involved in this project.

2. Economics of the management and biotic and abiotic stress. This includes weather, disease, drought and also pest component. Initially, the work will focus mainly on groundnut and then move on to pearl millet. Strong internal links will be required with the pathology and entomology units of groundnut and pearl millet groups.

3. Technology evaluation, adoption and impact appraisal. This project will initially deal with adoption of short-duration pigeonpea on a wider area across India and will also include perennial pigeonpea, etc. Close links with pigeonpea breeding and pulse agronomy will be maintained.

4. Human and social resources. Project will characterize farmers preferences, technical and managerial skills of farmers and their constraints to technology adoption.

DISCUSSION

The discussion centered around technology assessment at the farm level and the role of economists and agronomists in the design and transfer of technology.

- The agronomists in West Africa felt that there is need for interaction with economists in the areas of technology assessment. It was also suggested that economists should examine the impact of technologies developed by other agencies on our work.

- Another important issue raised was the extent to which NARSs should be involved in the development of technology. Many of the NARSs might not have adequate resources and it will be useful to work with them as collaborators. It was indicated that this is being done in Nigeria where local research institutes are involved in our socioeconomic data collection. It was also pointed out that in India such type of collaboration with the agricultural universities are working quite satisfactorily.

- It was noted that the length of the growing season will be relevant to economists too. It would be useful if economists can provide data on markets and other economic parameters to have a more complete understanding of the situation. If the economists could provide information on potential areas for ICRISAT mandate crops in non-traditional growing areas, then an agroclimatic survey of those areas could also be taken up. It was pointed out that CGPRT is compiling a large economic data base which could be used for this purpose.

- A project on the adoption of rabi sorghum in Maharashtra and HYV pearl millet in Rajasthan was suggested for study studied by the year 2000. The economists need to know the extent to which pearl millet fodder is used in Rajasthan. Rabi sorghum is an important source of fodder in parts of Maharashtra.

- It was suggested that research on biotic and abiotic stress is an important area of research in West Africa and that some studies should be initiated. There are also some important agronomic components in this area of study which should be considered. It was felt that initially the focus should be on crop improvement and then on shift to other areas later.

Natural Resource Economics

This thrust area which deals with physical land degradation and groundwater management was presented by Dr. T.S. Walker. These two components of the Natural Resource Economics thrust will involve extensive collaboration with the Soils Group. If adequate data are not available, it will be difficult to proceed effectively. Special funding has already been secured for the studies on physical land degradation. The second component on

groundwater management is mainly a synthesis type of study to encourage the judicious use of groundwater and the resource requirement for it would be very low.

DISCUSSION

- It was felt that this thrust area is very important as it involves all the groups of RMP. It was mentioned that ILCA is also starting a similar project in West Africa and in Mali, the SMSS project of USAID has also a component on soil conservation economics. It would be worthwhile to get in touch with these organizations.

- A question was raised with regards to the difference between the present project on groundwater and the earlier work done by Dr. M. von Oppen. The house was informed that Dr. von Oppen's project was concerned with water harvesting and an experimental type of exercise involving hydrologists etc. while the present study would involve a literature survey to gain a broader perspective of the problem particularly in hard rock regions. It was suggested that there will be more interest outside India for this type of work. In this connection the Limited Irrigated Dryland Concept (LID concept) from Texas A&M was also considered as an alternative to M. von Oppen's emphasis on irrigated crops.

Market and Policy Analysis

Drs. J. Baidu-Forson and R.A.E. Mueller presented research plans on market and policy analysis for West Africa and India respectively.

In the Sahelian Center, this thrust area will deal with the comparative advantage of ICRISAT mandate crops vis-a-vis substitute crops and evaluate implications of new sources of demand such as sorghum for making beer.

The difference between these studies and previous ones in this area by other economists was outlined. Only base data were collected in the previous studies and there were no demand studies for our crops. This work will complement the previous studies, and also the work being done in Mali by Dr. Adesina.

At ICRISAT Center the thrust area will include the following components:

1. World market description for mandate crops which will be mainly done by RMP.

2. Market impact of commodity research. This could best be done by economists outside the Institute on a contract basis.

3. Changes in demand for ICRISAT mandate crops, for instance demand for sorghum fodder in India and shift in demand for sorghum grain from food to feed. We do not have the necessary expertise to be involved in new uses of ICRISAT mandate crops.

4. Demand for mandate crops in new regions, for example pigeonpea in Thailand will continue with the help of collaborators.

5. Research needs of NARSs and national agricultural policies will require commodity specific studies for different countries.

7. Strategic behavior in research on traded commodities.

DISCUSSION

During the discussion it was pointed out that there is a need for more active collaboration between RMP and Crop Improvement Programs.

- There is also a need to have a closer link between breeders and economists to study the sorghum feed and fodder aspects.

- Even though ISNAR is already providing service to the NARSs, it was felt that RMP economists should be involved in a more specific area of work, for example, trade in pigeonpea or chickpea or impact of private seed industry in India.

Research on Research

Dr. R.A.E. Mueller presented research plans for this thrust which has two components, viz. (1) Agricultural research industry organization to know how a non-profit industry reacts to changes in its environment and where it can find its niche. This will involve external links with CGIAR, ISNAR and donor agencies, and (2) Managerial economics of agricultural research and development. This will identify techniques for determining research priorities and investigate ways and areas for research contracting with the main objective of improving cost effectiveness of ICRISAT's research.

DISCUSSION

- It was noted that in terms internal links only ICRISAT Management had been mentioned, although there was a need to have closer links at other levels too.

- Another issue discussed was links with national programs and the level at which they should be introduced. It was felt that NARSs should not be involved until more progress has been made in this area.

Session 8: Review of RMP Research Links.

This session considered both the internal and the external links of RMP research thrusts. Drs. J.M.J. deWet, Director of Cereals Program and D. McDonald, Acting Director of Legumes Program reviewed the internal links while Drs. B.K. Patel, Special Assistant to the DG on Strategic Research Affairs and I.P. Abrol, Deputy Director General, ICAR reviewed the external links.

Internal Links

Dr. de Wet expressed his concern about lack of cooperation between Cereals and Resource Management Programs because of compartmentalization of research at all levels (from Programs down to projects).

He indicated that many projects in the institute are designed for success. He cited an instance where scientists have used 12 years to identify 167 out of 30,000 sorghum collections that are resistant to midge. He also cited an example where 12 years or even more have been spent by scientists on screening 30,000 germplasm lines for resistance to stalk rot disease even though that disease is caused by as many as 25,000 pathogens and stressed that if there had been communication between pathologists and breeders or that if the scientists has used the library effectively, those 12 years would not have been wasted. He pointed out that so long as the Cereals Program has comparable positions for breeders, pathologists, agronomists and entomologists there will be very little cooperation between that Program and RMP. Where cooperation is needed by the Cereals Program (eg. expertise in screening), RMP or the Legumes Program cannot help. Consequently, Cereals Program has sought and obtained cooperation from the All-India Coordinated Programs to screen their materials for adaptation. The second part of cooperation which involves getting the screened materials to the farmer is done by the national and private seed companies who multiply the seeds and do the extension work to get it to the farmer.

If there is to be cooperation between Cereals Program and RMP, then there should be (i) changes in the research structure i.e. we need to change our themes or our projects to make them interdisciplinary; (ii) changes in the structure of the Programs. That is, we can either incorporate the Crop Improvement Programs into RMP as is being done in the regional programs like WASIP, LASIP and EASIP or change the present distribution of staff within the programs by having, for example, only one agronomist for all the Programs instead of one in each Program.

Dr. D. McDonald informed the house that there are very strong and productive links between the Legumes Program and the RMP. He

suggested that the Crop Improvement Programs and RMP should have collaborative research plans for East Africa and the SADCC region. He noted that a great deal of work has been proposed to be done in India but practically nothing has been proposed to cover the resource management problems relating to other Asian countries. RMP scientists' expertise would be needed in AGLN work. Specifically, Dr. McDonald indicated that Legumes Program would need assistance in evaluating new cultivars of groundnut, chickpea and pigeonpea in various cropping systems in Asia. He envisaged cooperation between RMP, IRRI's rice-based farming systems group, Legumes Program and AGLN cooperators. Legumes Program is also interested in cooperating with RMP scientists on disease and pest situations in intercrops and also in investigating the diseases and pests problems in organic matter/farm yard manure studies.

External Links

Dr. B.K. Patel expressed her serious concern about the communication problems within the institute and between ICRISAT and the NARSs. She did not expect ICRISAT to be able to work with all 49 NARSs in the SAT but she was concerned about the fact that the entire SADCC region seemed to be ignored by RMP. Some of the other important points mentioned by her were: (i) RMP and commodity research should work together, (ii) training is one area where ICRISAT can make maximum contribution in strengthening research capabilities of African NARSs; (iii) Directors of African NARSs should also be sponsored by ICRISAT to visit other regions of Africa in addition to India so that they can learn from each other; and ICRISAT should not only work with strong NARSs but also should work with smaller and weak NARSs. She also wanted some organisation to bring together anglo- and francophone NARSs. She emphasized that NARSs should not be treated as clients but as partners in research.

Dr. I.P. Abrol spoke on ICRISAT links with the Indian NARS. First he presented the future direction of agriculture in India. He said although in the past there has been more success in irrigated areas than dryland agriculture, the latter has also made some impact. By the year 2000, more than 50% of cultivated areas will still be under rainfed agriculture. For equity, and because of the need to increase production of oilseeds, pulses and cereals, rainfed agriculture will continue to be important in future and it is in this area that ICAR is always looking for links with ICRISAT. He indicated that the ICAR has been conducting a similar planning exercise in research as well as in their development departments. The salient points of their plan is that during the next ten years, emphasis will be on: (i) watershed-based management of rainfed agriculture which will constitute a major sector of development and (ii) prevention and reclamation of degraded lands. In these areas ICAR will entertain collaborative programs with either ICRISAT or other Institutes. Twenty-one agricultural universities in various

regions of India will be the nodal points for generation and extension of technology for their region. ICAR research stations will in future be involved in more strategic research. ICAR and Indian NARSs would like to continue cooperation with ICRISAT and other research organisations in the world on strategic research areas.

Dr. Abrol sought ICRISAT's cooperation in the following research areas: (i) watershed-based management program, which includes the area of surface hydrology, small watershed hydrology, methods of water conservation, methods of water recycling and reuse, problems of soil conservation etc.; (ii) resource characterization; (iii) land and water management and farm implement research; and (iv) research related to policy formulations.

DISCUSSION

The salient issues discussed were:

- **Cooperation**

  It was agreed that cooperation within and between programs is the means to efficiently achieve the goals of the Institute and Programs. Changing the organizational structure will not necessarily solve the problem of lack of cooperation within RMP and between RMP and the other Programs. Duplication of research between the research programs and support type of cooperation should be avoided. Cooperation between RMP and the other crop improvement programs and within RMP should be encouraged and strengthened.

- **Training**

  It was agreed that training of the middle level and higher level scientists in the NARSs will be an effective way of helping the weak NARSs.

- **NARSs**

  It was noted that some of the NARSs are very difficult to cooperate with. Others lack the support of their Government. Questions raised were: "How do you collaborate with the NARSs? What sort of collaborative projects? How much emphasis do you place in working with certain NARSs but not with others?" How do we communicate our research findings to the NARSs? No answers were given to these questions.

Session 9. Priorities and Commitments

PRESENTATION

Dr. J. Elston outlined a flow-chart of the interactions between NARSs, the assessment of biological and economic constraints and how management practices should be developed for adoption by farmers. Using this flow-chart he explained the strength and weakness of the RMP program and expressed the need for more interactions between the various groups in RMP. He was concerned that many of the activities in RMP appeared to be isolated from current agricultural practices.

Dr. R. Mueller explained in detail his concept of how priorities should be determined and how collaboration should be promoted. He favored the removal of barriers to spontaneous collaboration and the use of incentives to encourage interdisciplinary collaboration. Neither speaker dealt specifically with the ranking of thrusts into priorities nor the allocation of resources.

DISCUSSION

- **Comparison between RMP at ISC and IC.**

  Considerable attention was given to the apparent differences between the two RMPs largely because of the size of the centers and the strength of the national programs. At ISC the scientists are free to interact directly with farmers. At IC, the Village Level Studies form a good basis for establishing farmers' perspectives although village locations may not be conducive to work on crops such as millet. IC scientists tend to be concerned more with strategic problems than with site- and season-specific problems.

- **Communication and collaboration**

  Several ideas were exchanged for better communication and collaboration although no consensus was reached. Some supported the removal of administrative barriers and the creation of new incentives; others felt that collaboration should not be institutionalized, and that research should be separated from service activities.

- **Scale of research**

  The general opinion was that RMP should concentrate on the development of general principles and basic processes rather than development of packages of technology of the past. Research should be mainly at the level of a village, or of a defined ecological zone rather than of a whole district or region.

- **Collaboration with NARS**

  The collaboration with NARS depended on the perception and experience of scientists. One group favored working with NARS from the planning stage to ensure genuine interest in developing and testing the resulting technology or principle. The other group recommended the development of technology or management strategy on the research station, using NARS to test the final product. In India, where the NARS is strong and well-organised, the first approach was appropriate. In West Africa many NARS are weak and not organised so the second approach may be suitable e.g. OPSCAR.

Summing up by JLM, CR and YLN

- Dr. Monteith expressed the need for further discussion among RMP scientists to resolve controversies and uncertainties which had emerged during the Global Review. The major question was not about the identification of broad research thrusts but how to do the research. He emphasised the need to remove disciplinary boundaries by forming task forces to undertake the research thrusts.

- Dr. Renard explained how six thrusts were developed at ISC and expressed his concern for the "collaboration syndrome" which might not be useful in all research areas. ISC intends to pay some attention to the more favorable environment in the south and to collaborate with the two WASIPs.

- Dr. Nene described the rationale concerning the new project proforma which identifies the research responsibility of each scientists in the institute and should be completed by January 1990. He then listed the following thrusts which require further discussion with RMP and CIP scientists.

  a) **Organic matter**: need for deciding whether it is a priority issue and to determine the role of ICAR.

  b) **Crop variability at ISC**: An interdisciplinary approach should be adopted since it appears to be associated with numerous factors such as nutrient disorder, nematodes etc.

  c) **Weather and disease**: Concerned scientist to identify priorities with crop scientists.

  d) **Transfer of technology**: There should be more flexibility in the approach to transfer of technology depending on the strength of the NARS. Criticism of OPSCAR by the Africa Task Force is unfair.

  e) **Economist at SADCC**: The regional program is better placed to deal with SADCC problems and it is not advisable to do everything at IC.

f) **Identification of cooperators**: Greater care should be exercised in determining suitable collaborators e.g. it was difficult to see the role of the Indian Institute of Management in the groundwater proposal.

Finally, Dr. Swindale ended the review with the following comments:

Several RMP thrusts require further discussion; some may be disposable. The Environment chapter of the Strategic Plan should serve as an excellent checklist to develop projects.