SOCIO-ECONOMIC CONSTRAINTS TO THE FUTURE DEVELOPMENT OF THE DRYLAND FARMING REGIONS OF THE WORLD

Invited Address for
THE INTERNATIONAL CONGRESS ON DRYLAND FARMING
25 August - 5 September, 1980
Adelaide, South Australia

by

David F. NYGAARD
Agricultural Economist, Farming Systems Program
ICARDA, Aleppo, Syria

SUMMARY

SOCIO-ECONOMIC CONSTRAINTS TO THE FUTURE DEVELOPMENT OF THE DRYLAND FARMING REGIONS OF THE WORLD

by

David F. NYGAARD

There is a significant difference between what the dryland areas of the world could produce and what they are producing. This address explores the processes of creating, diffusing and adopting new technology and the constraints to this process. It suggests how we can identify those constraints that prevent closing this productivity gap.

The success of a new technology depends on its appropriateness to fit the agricultural environment and farmers' circumstances. It needs to be compatible with existing or potential resources, with farming systems and with socio-economic factors. Therefore, we must better understand the system we are trying to improve.

In order to do this, we need to have multidisciplinary research teams of social scientists as well as production scientists which involve the farmer in the research process. Such an approach aims at developing technologies that minimize the number of constraints farmers will face when they adopt a new technique and allow us to alleviate those constraints that remain.

Previous research has given us much valuable knowledge about farmer behavior when confronted with new techniques. Farmers are known to respond to economic incentives when making production decisions. Due to different

farmers' circumstances, both agro-climatic and socio-economic. New technologies will be location specific. Therefore, techniques which are transferred from one region to another, need to be adapted to the new environment in order to be successful. Farmers are unlikely to adopt complete "packages" of new technology. Rather, they initially choose those pieces that are most beneficial. Finally, farmers have control of fewer of the variables affecting them than we generally recognize. Prices which could be and perhaps should be increased by their governments are nevertheless fixed for the farmer.

Yet, there are other issues about which we know much less and thus, require our attention. Three areas crucial to dryland agriculture need to be better understood before we can greatly increase agricultural productivity in these regions. First, the livestock-cropping interface must be clarified. Farmers are not simply wheat producers or livestock producers -- they are both. Decisions relating to one activity also have implications for the other.

Secondly, risky production and risk attitudes are critical to dryland agriculture, particularly when producers are presented with new and uncertain technologies. Income stability may be as important as income levels and consequently, this affects production decisions regarding inputs, new techniques and even choices of farming activities.

Finally, learning is a process that improves farmers' perceptions of available choices and consequently can reduce errors which farmers make when experimenting with these new technologies. If the farmer understands a new alternative better, he will be more likely to make a considered decision about it, with a greater chance of adopting it. Our lack of understanding of these three areas maybe the biggest constraint to the future development of dryland agriculture.

New technology will spread if it benefits the farmer. To ensure that it does so, we need to slightly reorder our research toward involving the farmer, understanding his situation and identifying and alleviating those factors which are constraining his productivity. Since the productivity gap is large, the returns to such efforts can be substantial.

TABLE OF CONTENTS

		Page
I.	INTRODUCTION	1
II.	TOWARDS AN APPROACH TO INVOLVE FARMERS:	5
III.	TOWARDS UNDERSTANDING FARMERS	10
IV.	SPECIAL FOCUS: CONSTRAINTS(?) FOR THE FUTURE	16
	A. The Livestock-Cropping Interface	17
	B. Risk and Uncertainty	19
	C. Learning	21
V.	CONCLUDING REMARKS	24

4

SOCIO-ECONOMIC CONSTRAINTS TO THE FUTURE DEVELOPMENT OF THE DRYLAND FARMING REGIONS OF THE WORLD

I. INTRODUCTION

"The capacity of scientists to generate new (agricultural) technology outstrips our understanding of the social and economic implications of technical change." 1/ (Arndt and Ruttan 1977)

"A more sympathetic understanding of the conditions that persuade... farmers to accept technical agricultural innovations could facilitate increased food production as powerfully as the new technology itself." 2/ (Leagans 1979)

There is a very significant difference between what the dryland areas of the world could technically produce and what they are currently producing. This is particularly true in the developing countries. Closing this gap will go a long way towards meeting the demand for increased agricultural production during this decade. This address is based on these premises. It explores issues of creating, diffusing and adopting new technology, and more precisely identifies the constraints to this process.

A rich literature about constraints to increasing agricultural productivity is now emerging. This literature thoroughly documents the importance of socio-economic constraints to agricultural development.

"The owners or tenants of these small farms usually have difficulty in obtaining additional land; possess limited information on the use of new technology; encounter problems in obtaining access to credit and modern inputs; and are confronted with markets that are poorly organized and often offer unattractive prices." 3/

While Zandstra, et al. (1979), made this statement summarizing the socio-economic constraints facing a group of farmers in Colombia, it is a very typical description of development projects all over the world. Obviously, different authors studying different situations have identified different constraints. Generalizations are difficult to make. It would be a mistake, I feel, to use the time allotted to me summarizing this literature and simply reporting to you that agricultural credit was found to be a constraint in country X, land reform was binding in village Y, or that labor shortage at harvest inhibited adoption in district Z. Instead, it is more useful to discuss a fundamental finding of this recent research.

The problem is to identify the constraints. Once these have been identified, we have the tools available to alleviate them. We now realize that the problem is one of understanding how socio-economic variables and bio-physical or agro-climatic variables can be identified as constraining agricultural productivity. Perhaps more importantly, we must understand how these constraints can be avoided. It is a complex system that we need to sort out to solve this problem, yet, I believe progress has been made toward this end.

I suggest that the success of any new technology depends on its appropriateness to fit the system. As Arndt and Ruttan (1977) point out,

> "The capacity to develop technology consistent with physical and cultural endowments is the single most important variable accounting for differences in agricultural productivity among nations." 4/

This can only be defined from the view point of the farmer (i.e., decision maker) and the farming family. Leagans (1979), as well as Hardin (1979), stress this perspective.

"Indeed, for new technologies to significantly influence agricultural production, the farmers -- the real managers of the production function -- must not only adopt them but use them correctly." 5/

"... Technology will succeed because it is better. But better must be defined in terms of the decision-making criteria employed by farm families -- criteria that are not always understood and appreciated by scientists and policy makers." 6/

My objective is to challenge you to approach the task of increasing agricultural production from a slightly different perspective. Notice that I do not say from a new perspective because there is nothing new in this approach. Yet, in spite of some successful examples of reordering our agricultural research and development priorities, we are, in general, very slow to change. Indeed, it is we who appear to be the slow adopters.

Let me establish at the outset that I am not critical of the resources and efforts that have been allocated to the technical aspects of agricultural productivity research, nor do I question the successes of these efforts, e.g., the "green revolution". Rather, it is these efforts and successes that allow us to be optimistic about our potential to meet the increasing demand for food. It is due to these technical successes that we now need to study the adoption process itself.

Neither do I wish to dismiss the recognition given by production scientists and administrators to the importance of socio-economic research in agricultural development projects. This congress, which has a major focus on technical issues, clearly recognizes this importance by giving me the opportunity to stress socio-economic issues in this closing session.

My presentation is divided into three sections:

1) The first discusses some of the major research efforts that look at constraints to adoption and the development of new technology. These lead to an approach that involves the farmer in the research process.

2) The next section develops what we currently know about farmer's circumstances and his/her decision making behavior, and discusses some remaining issues that are still unclear.

3) The final section draws attention to a few special topics -- possible constraints -- that demand future consideration if we are really going to close the productivity gap.

Let us now discuss each of these three sections separately, first of all, the involvement of farmers in the research process.

II. TOWARDS AN APPROACH TO INVOLVE FARMERS

IRRI (International Rice Research Institute) has made perhaps the boldest attack on the problem of identifying the constraints to farmer adoption of new technology, in this case, for rice. Barker (1979) suggests that IRRI's evolution of a methodology to determine yield constraints was prompted by both low adoption rates of new varieties and huge differences between yields observed on farmers fields and those obtained on experimental plots.[7/] This gap -- the difference between present and potential yield levels in a particular environment -- became the focus of their research. Efforts to explain factors accounting for this gap were thus pursued. The results of this work indicate, among other things, that a large number of factors are involved, both technical and socio-economic, and that the interactions of these factors are very complex.

The three major groups which prevent attaining high yields from a particular technological package are:

1) physical and/or biological, e.g., soil characteristics preventing the realization of experiment station yields;

2) economic, e.g., unprofitable or risky attributes of the new technology; and

3) social, e.g., bottlenecks to the distribution of fertilizer.

Concentrating only on constraints at the farm level, De Datta, et al. (1978), observe that yield gap II in Figure 1 is a function of all of these constraints. The biological constraints explain what accounts for the gap, while the socio-economic constraints explain why the gap exists.

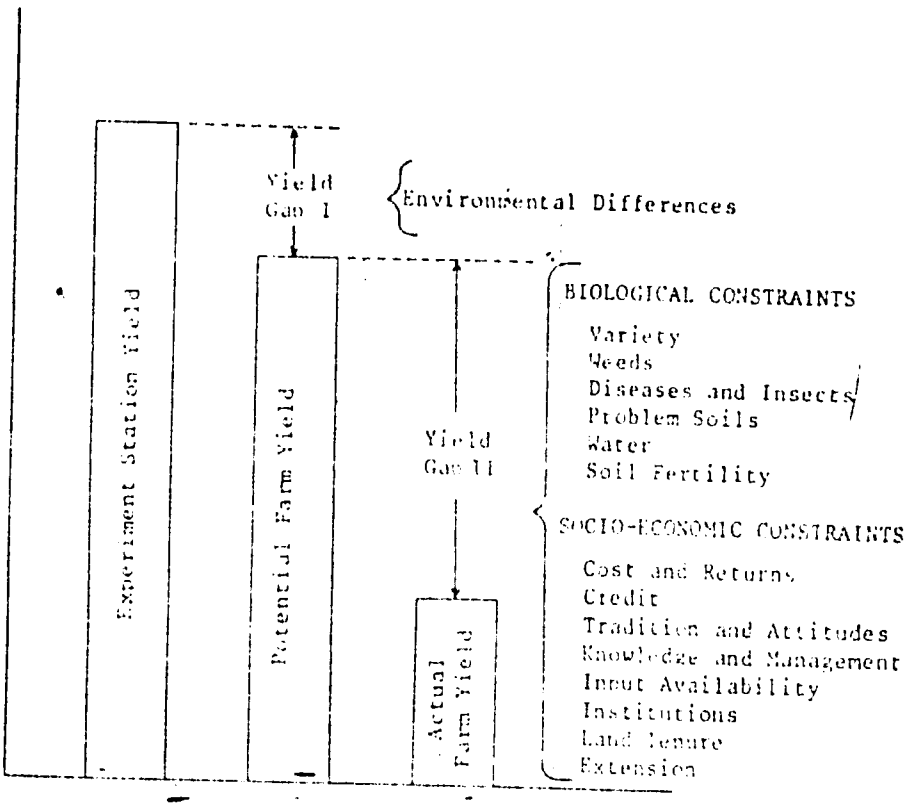

Figure 1 Yield Gaps

Source: De Datta, et al. A Methodology for an Integrated Experiment-survey on Rice Yield Constraints, 1978, pp. 7

Barker admits that identifying socio-economic factors which explain farmers' behavior is not an easy task, and that using these factors to account for the gap is more of an art than a science.[8/] Nevertheless, it seems to me that the next logical step, theoretically at least, is to borrow from the production scientists the concept of "the limiting factors". Brady (1974) states this principle as:

> "The level of crop production can be no greater than that allowed by the most limiting of the essential plant growth factors." 9/

Why not broaden and extend this principle to include all factors, socio-economic as well as bio-physical? Assume, for example, that an agronomist identifies phosphate as the major limiting factor in a particular environment. He determines that weeds, plant population, seed variety and finally nitrogen, in that order, are also technical constraints that limit production. If we can include all potential factors, the second limiting factor may not be weeds but the fact that the farmer does not understand the plant response to phosphate. Cash flow may be the next constraint which would require credit assistance. Then phosphate distribution may be constrained by an inadequate input-delivery system. Now agronomists can proceed to what is their second limiting factor, weeds, which is only fifth on our list. This helps all of us to see the contribution of those outside our discipline and gives us balance in setting research priorities.

Multidisciplinary research teams are the obvious response to such a perspective. The sources which I consulted in preparing this address overwhelmingly advocate such an approach. Schultz (1979) warns us not to become too "enamored of the phrase 'interdisciplinary research'" which is, in general, "weak on theory and soft on quality".[10/] Yet, I believe the social scientists along with the agronomists and soil scientists are necessary for the development and diffusion of new technology. This requires them to work together, each contributing his/her own expertise.

Frequently, of course, no single thing is limiting but several new techniques can be combined to achieve a substantial increase in yield: thus, the "package of new technology". This is a subject I will return to shortly, but I want to point out at this juncture that complete adoption of a technological package is very rare.

One problem with the approaches developed so far is that social scientists enter the research process only after the technology has been developed. A new technology is "produced", in isolation, on research stations and then is presented to farmers -- frequently by someone not involved in the research. All too often the economist sees his/her job as beginning only where the agronomist leaves off. The economist arrives at the last stage to analyze the results, often using a benefit-cost approach. These studies, showing what should have been done or what went wrong, have not endeared us to our production collegues who were doing the work.

CIMMYT's (International Maize and Wheat Improvement Center) Economics Program has made progress rectifying this ex poste socio-economic contribution. Byerlee, et al. (1979), involve social scientists at the initial stage in an effort to develop technologies which are appropriate to farmers and farmers' circumstances. The basic hypothesis of this approach is that our understanding of physical resources of the farm and the economic and social environment of the farmer will give much needed direction to the basic research activities on the experiment station as well as on farmers' fields. The resulting new techniques will be more quickly adopted because they "fit". The approach "emphasizes ex ante collaboration of technical and social scientists in on-farm research...."[11/]

"Appropriate" is the key word in the CIMMYT approach. Bunting (1978) puts it rather bluntly,

> "... The most important causes of failure are ... that the technology is inappropriate, irrelevant, unusable or ineffective, because it was designed to maximize yield rather than to resolve felt or real problems of real producers in real life systems with the real resources actually available." 12/

Who decides what is appropriate? We now arrive at the door step of the farmer. It is he who will make the final adoption decision. "... There is often a considerable difference between what the farmer really wants and what the politician, planner (and scientist) feel that he needs."13/ (Zandstra, et al. 1979). Not only CIMMYT and IRRI but others as well, emphasize both farmer contact and on-farm research as the cornerstone of their efforts. Sedcliff (unpublished manuscript) suggests, that one of Plan Puebla's successes was to get research onto farmers' fields. Farmer-researcher contact is needed to bridge the ex ante communication gap.

Farming systems research programs emphasize the farmer's role (given his/her environment and circumstances) in the research process. There is not yet complete agreement on a precise definition of such research but there is agreement that it (1) requires multidisciplinary team members, (2) involves the farmer at each and every stage of the research process and (3) includes all activities of the farm family -- crops, livestock, home consumption and off farm income, i.e., it is holistic in scope. As such, it proposes to alleviate the problems of traditional approaches.

Norman (1978) says it well. Farming systems research reveals

> "the constraint(s) most limiting in the system ... which then become a focal point for developing strategies to overcome them ... Many changes envisioned in farming systems research involve small adjustments in the system rather than complete changes. The role of the farmer is maximized and reality in the research process ensured by minimizing work on experiment station fields and maximizing it on farmers fields.... The research process is recognized as being dynamic and iterative, with backward linkages between farmer and research worker, rather than simply the presence of forward linkages." 14/

Farming systems research can increase agricultural productivity by increasing resources allocated to agriculture, partly with new resources but partly by using existing resources more effectively. There are many benefits of such an approach. One type of constraint noted by Bunting (1978) which is not easily identified outside farming systems research, is the competition for limited resources that comes not only from agriculture but also from all of the farming family's activities.

Such an approach is being increasingly used by the International Research Centers. At ICARDA (International Center for Agricultural Research in Dry Areas) farming systems research is intended to be a focal point of research activities. While our center is young, a farming systems approach appears to be a workable balance to the more traditional commodity-based research activities. By providing the link to the real farming situation, we are trying to serve an ex ante as well as ex poste role as ICARDA strives to develop appropriate new technologies.

A variation of such an approach was used in the rural development project at Caqueza, Colombia. The research team there attempted to balance the bio-physical and socio-economic requirements of a new technology with the bio-physical and socio-economic constraints of the farmers. Then they chose technologies with the fewest limiting factors. Simultaneously, they developed "buffer institutions" to alleviate constraints, particularly socio-economic in nature, that would occur as a result of the technology that was selected.[15/] This approach stresses the necessity of communication. The backward and forward linkages between the farmer and scientists are of paramount importance.

III. TOWARDS UNDERSTANDING FARMERS

The farmer involvement in the research process, will help clarify what we already know about farmers' behavior and circumstances, and what remains to be learned. Leagans (1979) notes that most studies have looked at the attributes of individual farmers by trying to identify socio-economic and socio-psychological characteristics of adopters, but the question why farmers do what they do has not been adequately considered.

I think some progress has been made toward answering this question. Schultz (1964) developed the hypothesis that the traditional farmer is generally efficient in the use of those inputs that are available to him. This hypothesis has been confirmed repeatedly (Hooper 1965, Massel 1967, and Yotopoulos 1968) and is now generally accepted.

Yet the world today, even in isolated agricultural areas, is confronted by change and thus, the farmer needs to be able to respond to a dynamic situation. Many authors emphasize the profound nature of the current changes in world agriculture, particularly in developing countries. "The technical task is not so much to do yesterday's job better, but to prepare realistic technology and means of enabling it to work for a very different future."[16/] (Bunting 1978). The revolution in energy prices -- certainly a revolution if there ever was one -- is one example. In the 1970's, Turkey developed an efficient wheat-clean fallow system requiring frequent cultivations as an efficient way to control weeds. The dramatic change in fuel prices undermines, and may eventually destroy, the viability of this high energy system.

Farmers do respond to socio-economic changes in their environment. At the macro level, Hayami and Ruttan (1971) explore the hypothesis that agricultural development is directed by a country's factor endowments, e.g., land and labor, and consequently, factor prices. Their theory of induced innovation shows that agriculture in countries with different resources have followed

different development paths. Japan, with relatively cheap labor and expensive land, has developed along a labor-intensive path using biochemical technologies. The United States, with cheap land relative to labor, has developed labor-saving technologies with a capital-intensive development pattern. Both countries achieved similar rates of growth in the agricultural sector. Relative factor scarcities induce technological innovations. Ruttan (1978) has broadened this theory to include institutional change as well, thus we can expect agricultural institutions to develop in a way that is consistent with prevailing economic conditions.

If technological and institutional change are endogenous to the system, factor endowments and prices, should help us to choose the kinds of new techniques that may work. Binswanger and Ryan (1977) apply this argument to guiding research. "Resources should be allocated to research on production factors such that the results will increase the productivity of those factors in relatively short supply more than the productivity of those in relatively abundant supply."[17/]

At the micro level, the farmer is economically rational even when faced with adoption decisions. Somel (1977) found Turkish cereals producers to be profit maximizers seeking economically feasible technology rather than technically perfect, yield-increasing packages. We will not be mistaken if we make similar assumptions in future efforts aimed at motivating farmers. Winkelmann (1976), who coordinated adoption studies for CIMMYT in seven different countries, describes the common departure point for their work. "The assumption is that farmers are income-seeking risk averters who are sensitive to the nuances of the environment in which they farm and are generally effective in their decision making."[18/]

There are, however, two related issues central to development projects which are often misunderstood. (1) We must recognize the location specific nature of agricultural technology. This will affect technological development and exposes the inherent problems of direct technical transfer. (2) We need to ask ourselves what factors the farmer has control over, and what factors are "fixed".

There is no shortage of warnings that agricultural production is location specific. As Perrin and Winkelmann (1976) note, "Agricultural technology is more site-specific than we were led to believe by some of the early successes with wheat and rice varieties."[19/] Bunting (1978) chides "there can be no universal technical prescription."[20/] Leagans (1979) implores us to realize that there are many important variables involved that "are highly situational in kind, relationship, and the relative influence they exert on the adoption behavior of (farmers)".[21/]

Agricultural production is location specific because regions differ and farmers differ. Perhaps this is one reason why farmers do not generally adopt complete technological packages.

Mann (1977) shows that in Turkey, farmers decide which pieces of the technology are most economically profitable and adopt those first. Redclift (unpublished manuscript), observing the problems with the maize package in Plan Puebla in Mexico, concludes that, "the package was new, to be sure, but the package was not adopted."[22/] He emphasizes this by noting that "participants accepted some practices with more alacrity than others; increasing the rate of nitrogen fertilization, but without changing their method of applying it."[23/] He also found that only partial adoption of some pieces occurred; for example, farmers increased plant densities but by less than was recommended. The Institute of Agricultural Science and Technology in Guatemala has even gone so far as to "abandon the idea of technological packages altogether."[24/]

If farmers do not adopt packages, it is important to identify those components of the package which could be or perhaps should be adopted first. Our work at ICARDA has shown preliminary indications that management of cultural practices may have a much greater potential for increasing cereal yields than the introduction of new varieties. We are now in the process of determining which of the practices are the most economically attractive to the farmer so as to order our priorities for on-farm research.

When we have recognized the differences among farmers we can then consider factors which explain these differences -- some the farmer can control and some are beyond his/her control. What do we accept as "given" when designing new technologies?

From the farmer's viewpoint many, if not most, things are assumed to be given, i.e., outside of his control. Barker (1979) recognizes this in IRRI's constraint work. The "physical environment -- soil, climate, water control -- and the institution environment -- farm size and tenure status -- are taken as given." They limit their efforts to constraints over which the farmers and researchers can exercise some control.[25/]

There are many other projects in which this is either not realized or not given enough importance. My concern is that we frequently take agro-climatic conditions as fixed but socio-economic variables as changeable. Socio-economic variables are within Man's control, but will they be changed at our suggestion? Should we encourage governments in the region to change prices to fit the technology we have developed elsewhere or should we look for more flexible technologies? One conclusion easily drawn from Distortions to Agricultural Incentives (Schultz 1979) is that governments have resisted manipulating policy variables, or at least have not manipulated them the way economists think they should.

I suspect the answer is to expect some government response but by no means complete change. Thus, we will need to find more flexible technologies for a world so diverse and better inform governments about implications of their actions, e.g., price policy.

As an illustration, look at the situation ICARDA faces. We are a research center in the Middle East serving some 22 countries stretching from Pakistan to Morocco. This region was clearly defined because of the similarity of agro-climatic conditions although we have both high plateau and low elevation research strategies. These conditions are accepted as given and not changeable. This is all right for technical research programs conducted in isolation of socio-economic circumstances. The possibility of finding a barley variety and accompanying package of cultural practices that has wide technical adaptability to the low elevation regions, for example, probably exists.

From the social scientists' viewpoint, however, the region is incredibly diverse. The socio-economic differences became very clear when similar wheat varieties and production techniques were recommended in Turkey and Algeria. The organization and structure of the agricultural sector in these two countries is drastically different. Different price ratios suggest that only by sheer chance would a similar technical package be appropriate for both countries. Consequently, the two efforts were not equally successful. Turkey has made great progress in increasing its cereal production while production in Algeria has stagnated. Apparently, the technology fit the Turkish environment better.

Differences can be more extreme between developed and developing countries. Technical assistance projects that attempt to transfer techniques created in high-income countries must be adapted to the new environment. This may be difficult to do. Examples of this are attempts to transfer the United States Pacific-northwest wheat-fallow system to Jordan or the Australian Ley farming system to Tunisia. Doolette (1977) has already addressed the congress with this second example and acknowledges the difference between technical feasibility and social and economic issues, e.g., the management problems he confronted.

Schmisseur (1978) points out that the Oregon State project in Jordan had minimal impact on adoption rates by farmers. Personal communication about that project suggests that this was due to the team's commitment to make the Pacific-northwest system work. The team lacked a comparative study of environmental conditions and resources and did not have an adequate understanding of existing practices and farming systems. Therefore, they were not able to modify the technology to Jordan's conditions. The lesson is clear: to be transferred successfully, technology needs to be compatible with existing or potential resources, with farming systems, and with socio-economic factors.

I need not stress the point further? This is why I feel it is important to address methodolgical issues to constraint identification not to the constraints themselves. The methodology is transferrable: the technology, without adaptation, is not.

IV. SPECIAL TOPICS: CONSTRAINTS(?) FOR THE FUTURE

I have refrained from discussing specific constraints but would like to briefly mention three topics that we need to understand better. They are not constraints as such, but our failure to understand them may be our biggest constraint in the future. I have found these issues to be important from my experience which has been focused in the Middle East, so the list is somewhat personal. It is not intended to be conclusive. However, I do think they are important and widely applicable to dryland farming.

Rainfed agriculture is always uncertain and frequently characterized by harsh conditions. Farmers working in such an environment need to diversify their income alternatives in order to minimize financial losses which can be disastrous for the future of their families. Decision making under these circumstances needs to be finely tuned, if farmers are going to be able to capture economic benefits whenever and wherever possible. The three topics I raise are central to understanding why a farmer does what he does in a dryland farming environment.

The first topic relates to the livestock-cropping interface that so dominates dryland farming. We now understand fairly well the economic forces that work on single crop agriculture, but we are still struggling with the economics of livestock production (White, et al. 1978). The interrelationship of the two is still very much a black box.

Risky and uncertain alternatives faced by risk averse producers is the second topic. Great progress has been made on understanding the importance of this issue, and some people are even ready to dismiss the subject as no longer debatable. I maintain that since new technology adds more uncertainty and we still do not understand how this uncertainty is perceived by farmers, further study is merited.

The final topic concerns the learning process a farmer undertakes when faced with a new alternative. Although this issue is complex -- involving questions of education, experience and information -- it is crucial in explaining adoption rates. Unfortunately, it receives very little attention in development programs.

I would like to briefly develop each of these issues within the framework which I presented earlier. The farmer is a central participant in a multidisciplinary farming systems research effort aimed at increasing agricultural production. Technical knowledge exists to affect increases and it is a matter of making it appropriate to farmers' circumstances.

A. The Livestock-Cropping Interface

I cannot improve on the description of the problem as found in Oregon State University's recent publication about dryland agriculture.

> "Farms in the world's dryland zones generally produce both cereals and livestock. Extensive research and development has focused on increasing the cereal production on these farms. Far less is known about the roles of livestock and forage in the total farm organization as well as the potential presented by expanded areas of complementarity between cereals and livestock." [6] (Dryland Agriculture Technical Committee 1979)

Here is an area of study where the value of a systems approach is not only useful but essential. To illustrate, let me construct for you some of the complexities of such a system as it exists in northern Syria. In some Syrian villages that ICARDA is studying, many farmers practice a three year cereal-lentil-watermelon rotation. Rainfall comes mostly in the winter and averages 300 mm/year. Cereal grain is both consumed at home and sold while the straw is gathered and fed to animals later in the year. The fields are also grazed after the harvest and some grazing may be done during the growing season as well. The lentil grains are mostly sold to the government for export while the straw, which farmers say is superior to cereal straw, is fed to

livestock. In a dry year, the price of lentil straw per kilogram can actually exceed the price of a kilogram of grain. Since lentils yield about 1.5 to 2 times as much straw as grain, the gross income from straw can often be higher than that of grain. Watermelon is grown as a cash summer crop, using residual water, and the field may be grazed at the end of the season.

What role do animals play in this system? The average farming family has about 20 sheep and goats. The animals graze on village common lands part of the year but are also part and parcel of the cropping system. Gross income coming from livestock production is 30 to 40 per cent, including home consumption of milk products.

ICARDA is very interested in knowing if and how forage production could fit into this system. Clearly, an understanding of the complexities of this existing system is required before change can be introduced. Understanding these factors is our current preoccupation.

Where does one begin to sort out the many interacting factors involved? Fitch and Nordblom (1977) made a start by considering the production possibilities. They suggest that we typically and erroneously view our dryland farmer as only a cereal producer. He/she is much more than that as the example shows. The forage-cereal possibilities for our farmer, given a fixed amount of land, are shown in Figure 2. Possibilities range from producing only cereals to producing only forage.

One can readily expand this model to multiple choices (including animal production) and introduce the home consumption versus market sales decision as well. Various programming models are at work in the developed world which help farmers make such complex decisions, but these are only partially successful. We have a poor understanding about livestock which is such an important part of rural family income and consequently should increase the allocation of research funds to the livestock sector and the cropping-livestock

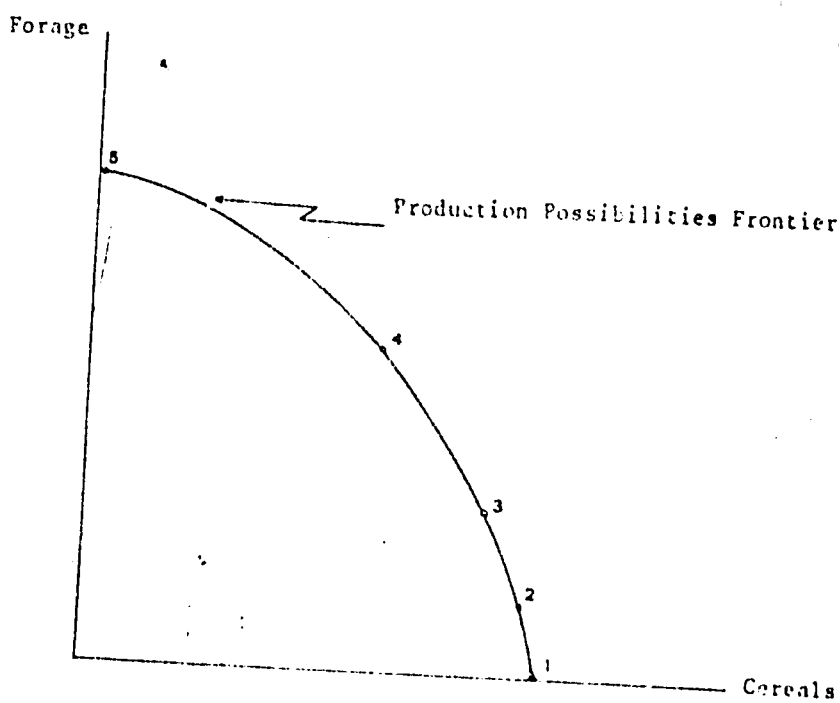

Figure 2 Forage-Cereal Production Possibilities

Where 1 = Cereal-clean fallow, no stubble grazing;
2 = Cereal-clean fallow, with stubble grazing;
3 = Cereal-fallow, grazing on stubble and on weeds during the fallow period;
4 = Cereal-forage crop rotation;
5 = Continuous forage crop (permanent pasture).

Source: James Fitch and Thomas Nordblom. "Agricultural Decision-Making in the Drylands." Proceedings of an International Symposium on Rainfed Agriculture in Semi-Arid Regions. 1977. P. 277

interface. The Oregon State report (Dryland Agriculture Technical Committee 1979) suggests that 3 factors characteristic to dryland agriculture, i.e., (1) increasing meat prices relative to cereal prices, (2) relatively abundant labor and (3) the possible greater importance of livestock to small farms (most of the world's farmers), tilt the balance toward livestock production and away from cereals. Thus, we should tilt our research priorities accordingly.

At this juncture I have no answers but want to ask two questions. First, do animals reduce the important income variability in dryland agriculture or is this a false bit of folk wisdom? Secondly, do farmers rapidly and accurately adjust to the many changes (take energy prices for example) in their environment?

E. Risk and Uncertainty

A number of empirical studies on risk and uncertainty have shown that risk aversion inhibits agricultural production (Ryan and Perrin 1974, Moulin 1975, Weina 1976, Moscardi 1977 and Nygaard 1979).[27] Applications to agriculture suggest that (1) farmers are for the most part risk averse and (2) agricultural production is risky, thus, inputs allocated to agriculture are less than they would be under conditions of profit maximization. In addition, new technologies are considered to be riskier than those now being practiced so adoption is delayed, or adoption is only partial since it is in the interest of a risk averse farmer to spread his risk by diversifying his production activities.

In Tunisia, I found that 73 per cent of the wheat producers included in my sample, were risk averse.[28] (Nygaard 1979). Similar evidence of risk aversion have been found elsewhere (Officer and Halter 1968, Scandizzo and Dillon 1976 and Binswanger 1977). The technique of determining risk preferences is not perfect and more work needs to be done, however the implications are of major importance.

Two farmers having similar physical resources will behave very differently if they do not have the same risk preference.[29/] This is no less than one more attack on the "package" technology. If this is true, a fertilizer recommendation requires a range of applications and outcomes so that the farmer can choose one that fits his risk preferences and other circumstances. As Moscardi and de Janvry put it, "... to be effective, new technologies and rural development programs need to be tailored to the attitudes toward risk...."[30/]

But there is more to it, particularly when considering new technical choices. Dillon (1971) points out that there are two necessary components for handling risk and uncertainty in expected utility theory: (1) personal valution of consequences and (2) personal strengths of belief about the occurence of uncertain events.

The second condition is crucial since it is not actual variability in production that is important but the perceived variability. Yields of a new variety for example, may have shown in experiments to be no more variable than yields of the old variety. If the farmer, with lack of experience and understanding of the new variety, thinks the yield to be more uncertain, he acts according. I found this to be the case in Tunisia by soliciting farmers' perceptions about the probability distributions of yields of both old and new varieties. Calculating the income caused by this output variability, I found that farmers perceived income from new varieties to be, on the average 37 per cent more variable.[31/] For some farmers this figure is much higher. Plant breeders in Tunisia argue that new varieties are not more variable than old. Perhaps so, but it is the farmers that have to be convinced.

The result is that these farmers use less amounts of inputs than profit maximization criteria call for. They also resist adopting the new varieties even though they expect these new varieties to produce higher yields. In the Tunisian case, the more risk averse the farmers were, the more slowly they adopted the new varieties. We often give the risk and uncertainty question lip service and then proceed as if it were not there.

Hiebert (1974) does not miss this point about new technologies. "... As the innovation process proceeds, decision makers obtain additional information which reduces uncertainty and hence the possibility of making allocative mistakes".[32/] Risk and uncertainty and the learning process are very much interrelated.

C. Learning

> "And there is always the possibility that aspects of the technology may not be understood by the farmers or by those directly advising them." 33/ (de Datta, et al. 1978)

Perceptions of output, and consequently income variability, are important but the farmer also has perceptions of the production process itself. He has perceptions about the parameters of the production function and it is quite normal to expect these perceptions to be characterized by subjective probability distributions.

Since agriculture is a dynamic process, adjustment to change is just as important as the change itself. This is equally true in the developed world as the developing world, but it is the slower adjusters that concern us. These producers, an important potential source of productivity growth, are more likely to be found in the developing countries. Typically, they are, among other things, illiterate, isolated from the information center, and infrequently contacted by the extension services.

Nelson and Phelps (1966) saw the importance of education by noting that it "enhances one's ability to receive, decode, and understand information...."[34/] Welch (1970) subsequently divided education's contribution to production processes into two effects, (1) the worker effect is the marginal productivity of education, i.e., education is a separate input into the production function, and (2) the allocative effect is "... a worker's ability to acquire and decode information about costs and productive characteristics of other inputs."[35/] We are concerned here with the second.

Many other studies have been concerned with this theme (Huffman 1974, Khaldi 1975, Wu 1977 and Nygaard 1979). Learning is judged to be increasingly important in the adoption and adaptation processes. Similar variables such as information, experience, and extension services are equally important for improving the producer's expectations or perceptions of available alternatives.

Farmers are required to make production decisions several months before their results will be achieved. During the production cycle, many things can happen that are beyond the farmer's ability to control. I found significant differences in Tunisia between what farmers expected and what they actually received (Nygaard 1979). I estimated two production functions; one based on farmers' perceptions at the time of planting, and a second based on actual yields at harvest. Inaccurate perceptions lead some farmers to make large allocative errors.

Farmers made larger errors in the production of new wheat varieties than traditional varieties. Those farmers on flat valley land close to the towns, and thus near the sources of information, were also more efficient than hillside, more isolated farmers. Also, the more efficient producers of new varieties were those who had more years of experience growing them. As these producers gained experience in using the new varieties, their expected yields increased as well. Learning by doing improves farmers' decision-making ability.

If farmers actually make decisions based on some perceptions which are constantly in a state of change, this has profound implications for diffusing new techniques. We should contact farmers with a view toward encouraging them to learn, and helping them adjust to new situations. More importantly, small simple technical changes will reduce farmers' chances of making allocative errors. (Roe and Nygaard, in press). Many Tunisian farmers told me that they had tried a rather complex package earlier, and it had failed. They had returned, in the following season, to their old technology; one they knew better.

Gafsi and Roe (1979), in an earlier study on cereal production in Tunisia, found that new durum wheat varieties were neutral with respect to the inputs, i.e., the production function just shifted upwards. On the other hand, the new bread wheat varieties were non-neutral. See Figure 3. The greater difficulty on the part of farmers in learning the new bread wheat technology may explain in part the slow rate of adoption of these varieties in Tunisia. The adoption rate of durum wheat was higher. This was particularly true for small farmers.

In a dynamic agricultural setting, allocative errors are made if a producer cannot adjust immediately and accurately to new circumstances. It is fairly well accepted that education, information, and experience all contribute to reducing this error. If we can aim our work in on-farm trials, demonstrations and extension toward improving this learning process, adoption of new techniques will proceed much faster.

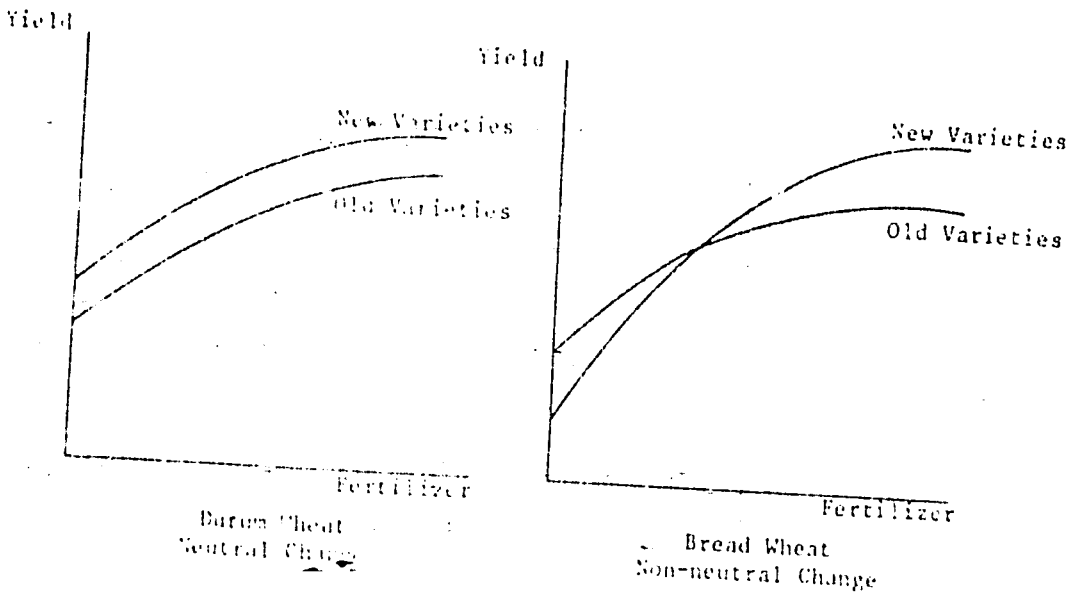

Figure 3 Different Technical Changes

V. CONCLUDING REMARKS

The productivity gap can be closed by producing appropriate technology for farmers where possible, and identifying constraints to the adoption of new technology where necessary. I propose that a micro-level approach with multidisciplinary teams, including the farmer, working on the farmers fields, will solve many of the problems found in more traditional research. Output will increase, income should do likewise, and agricultural and rural development can progress.

My presentation is mainly concerned with the smaller, poorer farmers because this is where the gap exists. Larger farmers, particularly in developed countries, are more likely to face technological constraints rather than socio-economic constraints. Other speakers in this congress have addressed that topic.

Small farmers are small only in size of land holding, but not in numbers since they include more than 100 million farming families. Their sheer number justifies the focus of this presentation. They require technologies that (1) are economically viable, (2) do not increase income instability, (3) do not demand major adjustments, and (4) fit their circumstances. A complete package of technology is not likely to be adopted immediately. Nor does transferring techniques from one region to another have a high probability of success unless socio-economic factors are considered.

I have not constructed a ranking of socio-economic constraints. I have not even discussed some of the important ones. I suspect that most economists treating this subject, would concentrate on economic incentives and disincentives. My brief treatment of that issue does not mean that I think that these things are unimportant.

Rather, I have attempted to stress the importance of knowing how constraint[illegible]n be identified. Three areas will help us in the future if we unc[illegible]and them better. They are the livestock-cropping interface, risk and uncertainty, and the farmers' learning process. I recommend allocating more research funds and efforts to solve these problems.

What, then, are the socio-economic constraints to the future development of the dryland regions of the world? There are really only two. I am the first and you are the second.

NOTES
* * * * *

1/ Thomas M. Arndt and Vernon W. Ruttan. "Valuing the Productivity of Agricultural Research: Problems and Issues." Resource Allocation and Productivity. 1977, p. 21.

2/ J. Paul Leagans. Adoption of Modern Agricultural Technology by Small Farm Operators: An Interdisciplinary Model for Researchers and Strategy Builders. 1979, p. 3.

3/ Hubert Zandstra, et al. Caqueza: Living Rural Development. 1979, p. 21.

4/ Arndt. op. cit., p. 3.

5/ Leagans. op. cit., p. 3.

6/ Lowell S. Hardin. "Emerging Roles of Agricultural Economists Working in International Research Institutions such as IRRI and CIMMYT." Invited paper given at The 17th International Conference of Agricultural Economists. 1979, p. 39.3.

7/ Randolph Barker. "Adoption and Production Impact of New Rice Technology -- the Yield Constraints Problem." Farm-Level Constraints to High Rice Yields in Asia: 1974-77. 1979, p. 1-26.

8/ Ibid., p. 22.

9/ Nile C. Brady. The Nature and Properties of Soils. 1974, p. 19.

10/ Theodore W. Schultz. "The Economics of Research and Agricultural Productivity." IADS Occasional Paper. 1979, p. 6.

11/ Derek Byerlee, et al. "Toward a Methodology for Developing Technologies Appropriate to Farmers." Paper given at The 17th Conference of the International Association of Agricultural Economists. 1979, p.1.

12/ A. H. Bunting. "Science and Technology for Human Need, Rural Development and the Relief of Poverty." OECD Workshop on Scientific and Technological Cooperation with Developing Countries. 1978, p. 21-22.

13/ Zandstra. op. cit., p. 12

14/ D. W. Norman. "Farming Systems Research to Improve the Livelihood of Small Farmers." American Journal of Agricultural Economics. 1978, p. 815.

15/ Zandstra. op. cit., pp. 255-7.

16/ Bunting. op. cit., p. 6.

17/ Hans P. Binswanger and James G. Ryan. Efficiency and Equity Issues in Ex Ante Allocation of Research Resources. 1977, p. 2.

18/ Winkelmann, Donald. The Adoption of New Maize Technology in Plan Puebla, Mexico. 1976, p. vi.

19/ Richard Perrin and Donald Winkelmann. "Impediments to Technical Progress on Small Versus Large Farms." American Journal of Agricultural Economics. 1976, p. 893.

20/ Bunting. op. cit., p. 6.

21/ Leagans. op. cit., p. 21.

22/ Michael Redclift. Production Programs for Small Farmers: Plan Puebla as Myth and Reality. The Ford Foundation. 1979, p. 29.

23/ Ibid., p. 12.

24/ Ibid., p. 31.

25/ Barker. op. cit., p. 17

26/ Dryland Agriculture Technical Committee. Dryland Agriculture in Winter Percipitation Regions of the World. 1979, p. 16.

27/ See Anderson, et al. for an excellent treatment of risk and uncertainty in agriculture.

28/ David F. Nygaard. "Risk and Allocative Errors due to Imperfect Information. The Impact on Wheat Technology in Tunisia." 1979, p. 75.

29/ Binswanger found that farmer in the semi-arid tropics in India were risk averse and the range of aversness was small. Thus, they will use less input than profit maximizers but behave in a similar way. This is quite different to Scandizzo and Dillon's results.

30/ E. R. Moscardi and Alain de Janvry. "Attitudes Toward Risk Among Peasants: An Econometric Approach." American Journal of Agricultural Economics. 1977, p. 710.

31/ Nygaard, op. cit., p. 78.

32/ Dean L. Hiebert. "Risk, Learning and the Adoption of Fertilizer Responsive Seed Varieties." American Journal of Agricultural Economics. 1974, p. 764.

33/ S. K. de Datta, et al. A Handbook on the Methodology for an Integrated Experiment-Survey on Rice Yield Constraints. 1978, p. 3.

34/ Richard R. Nelson and Edmund S. Phelps: "Investments in Humans, Technological Diffusion and Economic Growth." American Economic Review. 1966, p. 69.

35/ F. Welch. "Education in Production". Journal of Political Economics. 1970. p. 42.

BIBLIOGRAPHY

Anderson, Jack R., John L. Dillon and J. Brian Hardaker. Agricultural Decision Analysis. Ames, Iowa: The Iowa State University Press, 1977.

Arndt, Thomas M., Dana G. Dalrymple and Vernon W. Ruttan. Resource Allocation and Productivity. Minneapolis: University of Minnesota Press, 1977.

Barker, R. "Adoption and Production Impact of New Rice Technology". Farm-Level Constraints to High Rice Yields in Asia: 1974-77. Ed. IRRI. Los Banos. International Rice Research Institute, 1979.

Binswanger, Hans P. "Risk Attitudes of Rural Households in Semi-Arid Tropics." International Crops Research Institute for the Semi-Arid Tropics, 1977.

Binswanger, Hans P. and James G. Ryan. Efficiency and Equity Issues in Ex-Ante Allocation of Research Resources. ICRISAT, 1977.

Brady, Nile C. The Nature and Properties of Soils. New York: McMillan Publishing Co., Inc., 1974.

Bunting, A. H. "Science and Technology for Human Needs, Rural Development and the Relief of Poverty." OECD Workshop on Scientific and Technological Cooperation with Developing Countries. Paris: April, 1978.

Byerlee, Derek, Stephen Biggs, Michael Collinson, Larry Harrington, Juan Carlos Martinez, Edgardo Moscardi and Donald Winkelmann. "Toward a Methodology for Developing Technologies Appropriate to Farmers." Paper read at The 17th Conference of the International Association of Agricultural Economists. Banff, Canada: 1979.

De Datta, S. K., K. A. Gomez, R. W. Herdt and R. Barker. A Handbook on the Methodology for an Integrated Experiment-Survey on Rice Yield Constraints. Los Banos, Philippines: IRRI, 1978.

Dillon, J. L. "An Expository Review of Bernoullian Decision Theory in Agriculture: Is Utility Futility?" Review of Marketing and Agricultural Economics. 39 (March, 1971): 3-80.

Doolette, John B. "The Application of the Australian Ley Farming System in North Africa." Proceedings of an International Symposium on Rainfed Agriculture in Semi-Arid Regions. Ed. Glen H. Cannel. Riverside, California: Consortium for Arid Lands Institute, 1977. 589-608.

Dryland Agriculture Technical Committee. Dryland Agriculture in Winter Precipitation Regions of the World. Corvallis, Oregon: Dryland Agriculture Technical Committee, 1979.

Fitch, James B. and Thomas L. Nordblom. "Agricultural Decision-Making in the Drylands." Proceedings of an International Symposium on Rainfed Agriculture in Semi-Arid Regions. Ed. Glen H. Cannel. Riverside, California: Consortium for Arid Lands Institute, 1977. 273-94.

Gafsi, Salem and Terry Roe. Adoption of Unlike High Yielding Wheat Varieties in Tunisia. Staff Paper 77-15. Department of Agricultural and Applied Economics, University of Minnesota, 1977.

Hardin, L.S. "Emerging Roles of Agricultural Economists Working in International Research Institutes such as IRRI and CIMMYT." Plenary and Invited Papers, The 17th Conference of the International Association of Agricultural Economists. Banff, Canada: 1979.

Hayami, Y. and V. W. Ruttan. Agricultural Development: An International Perspective. Baltimore: Johns Hopkins University Press, 1971.

Hiebert, L. Dean. "Risk, Learning and the Adoption of Fertilizer Responsive Seed Varieties." American Journal of Agricultural Economics. 56 (November, 1974): 764-768.

Hopper, W. D. "Allocation Efficiency in a Traditional Indian Agriculture." Journal of Farm Economics. 47 (August, 1965): 611-624.

Huffman, Wallace, E. "Decision Making: The Role of Education." American Journal of Agricultural Economics. 56 (February, 1974): 85-96.

Khaldi, Nabil. "Education and Allocative Efficiency in U.S. Agriculture." American Journal of Agricultural Economics. 57 (November, 1975): 650;657.

Leagans, J. Paul. Adoption of Modern Agricultural Technology by Small Farm Operators: An Interdisciplinary Model for Researchers and Strategy Builders. Ithaca, New York: Cornell University, 1979.

Lin, William, G. W. Dean, and C. V. Moore. "An Empirical Test of Utility vs Profit Maximization in Agricultural Production." American Journal of Agricultural Economics. 56 (August, 1974): 497-508.

Mann, Charles K. "Packages of Practices: A Step at a Time with Clusters?" Paper presented at the Meeting of the American Agricultural Economics Association. 1977.

Massel, B. F. "Farm Management in Peasant Agriculture: An Empirical Study." Food Research Institute Studies 7. No. 2 (1967): 205-215.

Moscardi, E. R. and Allan de Janvry. "Attitudes Toward Risk Among Peasants: An Econometric Approach." American Journal of Agricultural Economics. 56 (November, 1977): 730-738.

Nelson, Richard, and Edmund S. Phelps. "Investments in Humans, Technological Diffusion and Economic Growth." American Economic Review. 56 (May, 1968): 59-75.

Norman, D. W. "Farming Systems Research to Improve the Livelihood of Small Farmers." American Journal of Agricultural Economics. 60 (December, 1978): 813-818.

Nygaard, David F. "Risk and Allocative Errors due to Imperfect Information: The Impact on Wheat Technology in Tunisia." Ph.D. Thesis, University of Minnesota, 1979.

Officer, R. R. and A. N. Halter. "Utility Analysis in a Practical Setting." American Journal of Agricultural Economics. 50 (May, 1968): 257-277.

Perrin, Richard and Donald Winkelmann. "Impediments to Technical Progress on Small Versus Large Farms." American Journal of Agricultural Economics. 58 (December, 1976): 888-94.

Roe, Terry and David Nygaard. "Allocative Error and Risk: Wheat Production in Northern Tunisia." Extension Bulletin. University of Minnesota. In Press.

Ruttan, V. W. "New Rice Technology and Agricultural Development Policy." Economic Consequences of the New Rice Technology. Los Banos, Philippines: IRRI, 1978.

Ryan, James and R. Perrin. "Fertilizer Response and Income Gains for Potatoes in Peru." American Journal of Agricultural Economics. 56 (May, 1974): 337-343.

Scandizzo, Pasquale L., and John L. Dillon. "Peasant Agriculture and Risk Preferences in Northeast Brazil: A Statistical Sampling Approach." Paper presented at the CIMMYT Conference. Mexico: 1976

Schmisseur, "Economic Evaluation of Dryland Wheat Technologies Introduced in Jordan." Amman, 1978. United States Agency for International Development in Jordan.

Schultz, T. W. Transforming Traditional Agriculture. New Haven: Yale University Press, 1964.

_____. (Ed) Distortions to Agricultural Incentives. Bloomington, Indiana: Indiana Unviersity Press, 1978.

_____. "The Economics of Research and Agricultural Productivity." IADS Occasional Paper. 1979.

Somel, Kutlu. "Economics of Improved Dryland Wheat Technology: A Case Study of Ankara, Turkey." Ph.D. Thesis. Stanford University. 1977.

Welch, F. "Education in Production." Journal of Political Economics. 78 (January-February, 1970): 35-59.

White, D.H., B. R. Elliot, M. J. Sharkey and T.G. Reeves. "Efficiency of Land-Use Systems Involving Crops and Pastures." The Journal of the Australian Institute of Agricultural Science. (March, 1978): 21-27.

Wiens, Thomas B. "Peasant Risk Aversion and Allocative Behavior: A Quadratic Programming Experiment." American Journal of Agricultural Economics. 58 (November, 1976): 629-635.

Winkelmann, Donald. The Adoption of New Maize Technology in Plan Puebla, Mexico. Mexico City: CIMMYT, 1976.

Wolgin, Jerome M. "Resource Allocation and Risk: A Case Study of Smallholder Agriculture in Kenya." American Journal of Agricultural Economics. 57 (November, 1975): 622-30.

Wu, Craig C. "Education in Farm Production." American Journal of Agricultural Economics. 59 (November, 1977): 699-709.

Yotopoulos, P.A. "On the Efficiency of Resource Utilization in Subsistence Agriculture." Food Research Institute Studies 8. No. 2 (1968): 125-35.

Zandstra, Hubert, Kenneth Swandberg, Carlos Zulberti and Barry Nestel. Caqueza: Living Rural Development. Ottawa: IDRC, 1979.