Dr. J.D. Swindale

INSTITUTE SEMINAR
July 28, 1981

NEW DIRECTIONS FOR RESEARCH IN PRODUCTION ECONOMICS

Thomas S. Walker
Production Economist

Economics Program
ICRISAT
Patancheru P.O.
Andhra Pradesh 502 324 India

NEW DIRECTIONS FOR RESEARCH IN PRODUCTION ECONOMICS

Thomas S. Walker

This background paper does not inventory and chart new research directions for all areas of production economics in the Economics Program. Rather it concentrates on general research themes outlined in the 10-year plan that I will be directly responsible for or heavily involved in. These areas are designated by asterisks in Table 1 and encompass research on adoption, risk, and traditional farming systems.

Because adoption and related constraints analysis comprises a new topic on our research agenda, justification for new research directions is treated at length. New initiatives in research on risk builds on past ICRISAT studies. Research on access to rural financial markets is proposed in the context of constraints analysis. Yield gap analysis in dryland agriculture and determinants of yield in traditional cropping systems are also discussed under constraints analysis. The paper concludes with some thoughts on how we can best integrate our research efforts for appropriate training of our cliental, namely economists working in national agricultural research programs.

Because the Agricultural Development Council, my other parent organization, has a geographic mandate largely restricted to Asia I will focus but not confine my remarks to India. Throughout the paper, I take special pains to point out for each research area not only where I feel ICRISAT should be involved but also where it is not in the interest of the institute to spend scarce resources on economic research. Hopefully, such a contrast

Table 1. Major research areas and priorities for the ICRISAT economics program in India in the 1980s.

Major research area	Priority
Analysis of traditional farming systems**	1
Assessment of prospective technologies*	2
Social organization	3
Market scenario analysis	4
Studies of traditional tanks	5
Risk studies***	6
Adoption constraints***	New Area
Environmental and common property resources*	New Area
Alternative energy sources	New Area

* denotes involvement
** denotes heavy involvement
*** denotes major responsibility

Source: Constructed from the ICRISAT 10-year plan.

of what to do and what not to do will stimulate discussion and help obtain a concensus on a cohesive research focus. I will also follow the lead of previous seminar participants to spell out my thinking on some admittedly controversial issues that are critical to the success of the research and training program.

ADOPTION STUDIES

Why adoption research?

Adoption research by International Agricultural Research Centers is not without precedent. In the early 1970s, the Economics Program at CIMMYT commissioned a number of varietal and fertiliser adoption studies on maize and wheat. Results from these studies provided justification for the research focus that has prevailed in the CIMMYT Economics Program, particularly in their outreach efforts. IRRI has also recently devoted more attention to adoption research in conjuction with yield gap analysis in South and Southeast Asia.

There are two major reasons why ICRISAT should be interested in adoption research. First, adoption studies can furnish information useful in the design of improved technologies by ICRISAT scientists. Specific ways adoption studies can help in technology design are discussed in depth later in this section. Secondly, a knowledge of adoption is an essential building block for impact assessment which will likely be an area of rging interest to donors and host governments. As the institute matures, ations regarding diffusion of ICRISAT products - ideas, methodologies, or early breeding material targeted for natural program scientists or new cultivars and practices oriented at farmers - will also grow.

The relation between impact assessment and adoption research merits more discussion. The ways economists analyze impact can be grouped into ex-ante (before-hand) or ex-post (after-the-fact) evaluation and into general (and usually large) or partial (static and small) equilibrium models. Perhaps more than 90 percent of the impact statements on agricultural research have been assessed with an ex-post, partial equilibrium approach outlined in Figure 1. Agricultural research in this conceptual model leads to increased production which is equivalent to shifting the supply curve from SS to S'S'. Increased supply in turn results in a lower price and generates benefits to society of area BEN (S_0ABS_1). BEN is measured as the product of the increase in yield attributable to the innovation and the estimated rate of adoption. Jointly these two pieces of information determine the size of the supply curve shift, which is the most important and sensitive parameter in the analysis. If information on adoption is absent, it is not feasible to operationalize the model. Likewise, ex-ante evaluation with a partial equilibrium approach also requires predictions on the expected rate of adoption by innovation.

Simple models like these can be faulted because they are based on many assumptions, but they do provide fairly reliable and clean guidelines on economic consequences. More elaborate general equilibrium models require a greater investment in time and resources. Those models are geared to answer questions on the differential impact to different groups in society from the diffusion of improved technologies. The market scenario analysis addresses such concerns, but it also needs information on changes in production that contain implicit or explicit forecasts on adoption.

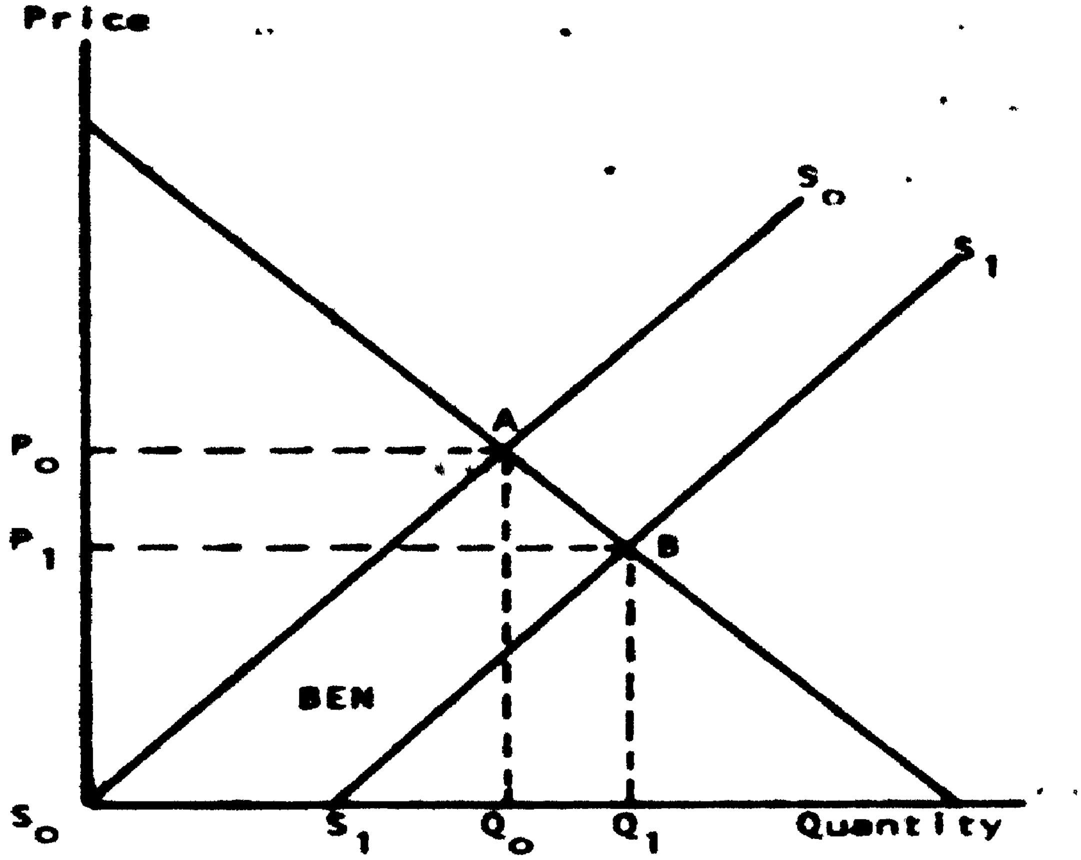

Figure 1. Economic evaluation of the impact of new technologies

Source: Hertford & Schmitz in Arndt *et al*. p. 155.

As a sidelight to this discussion, impact assessment at ICRISAT will be a daunting and challenging task and will call for a close working relationship between biological scientists and economists. It is relatively easy to evaluate the impact from adoption of a high-yielding cultivar such as a maize hybrid or a dwarf rice variety in a high fertility, assured rainfall or irrigated environment; it is much more problematic to estimate the impact of enhanced yield stability or quantify increases in yield attributed to improved disease, insect, and environmental resistance in a low fertility, dryland SAT environment. Crop loss and level of infestation surveys by entomologists and pathologists should prove useful in this regard.

What type of adoption research?

While one can make a good case for ICRISAT support for adoption research, such research has to be carefully defined and well-focused. ICRISAT should only be interested in a narrow range of adoption questions, specifically those that impinge directly on the institute's agricultural research mandate.

The adoption literature is immense and cuts across a number of disciplines, but it can somewhat arbitrarily be classified into the following three types of studies: (1) early acceptance, (2) diffusion, and (3) late adoption. This typology is based on the Adoption-Diffusion cycle for agricultural innovations.

The Adoption-Diffusion cycle

The adoption of successful agricultural innovations follows a pattern that is often summarized by a logistic or similar S-shaped curve (Griliches, 1957).

A logistic pattern does not always obtain, but it is a useful construct from which to classify adoption studies. Diffusion nonlinearly gathers momentum as information about the innovation spreads to more farmers. In Figure 2, curve 1 depicts the rapid diffusion of a superior innovation like hybrid maize in Iowa or HYV wheat in the Punjab where the adoption cycle was completed in only about five years. Most innovations diffuse much more slowly as reflected by the second logistic curve in Figure 2.

Rural social scientists have documented stages of awareness, interest, evaluation, trial, and finally adoption underlying the adoption-diffusion process. When farmers have had enough time to experience the first three or four stages, they often reject the innovation causing the rate of adoption to plateau out at a rate significantly less than 100%. Ten to twenty years after the innovation was first introduced it is not uncommon to find that a first-generation cultivar or practice has "matured" or levelled off at such a ceiling level of adoption.

Most investigators have focussed their attention on the diffusion phase of the logistic curve. They have lookod at who first adopts, how information spreads among farmers and how intervening variables such as extension contacts, extension knowledge, and sources and channels of communication condition diffusion.

Implicit in this focus is an assumption that the innovation is desirable; therefore, the characteristics of the innovation are not analyzed in depth nor is their interaction with the environment described. The results from these studies are largely directed at improving extension efficiency in the transfer of technology. For le, an ongoing World Bank sponsored

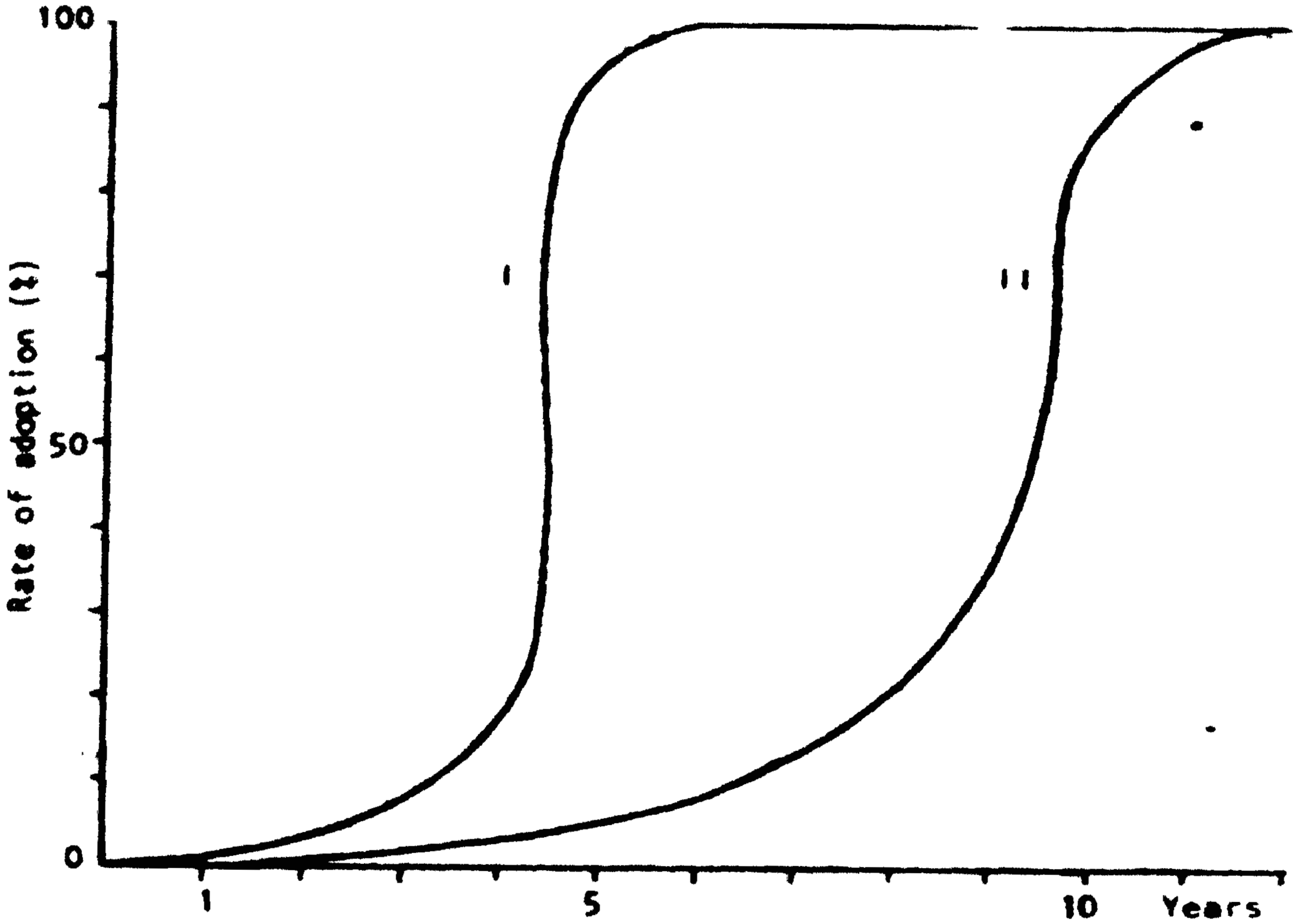

Figure 2. The adoption-diffusion cycle and logistic curves

evaluation (Slade, 1980) of the T and V system in Haryana falls into the mode of a al diffusion study.

Moreover, an understanding of the diffusion process and allied issues related to the speed of adoption does not generate much insight on the impact of technology on rural welfare. Unless early adoption by a few precludes later adoption by the majority, levels of rural welfare are determined by who ultimately adopts rather than by who first adopts (Gerhart, 1975).

For these reasons the bulk (perhaps 90%) of adoption research does not directly apply to agricultural research institutions such as ICRISAT. In contrast, the evaluation of late adoption and early acceptance studies have genuine potential to generate findings that are relevant to agricultural research on issues of technology policy.

Evaluation of late adoption

The purpose of this type of adoption research is to explain why mature innovations reach different ceiling levels of adoption across different regions. In a farming systems research context, one can view this type of research as base data adoption analysis. Because ceiling levels of on are frequently determined by edaphic, agroclimatic, and biological variables, results often contain implications for technological policy. For example, while the CIMMYT early 1970s studies were not strictly of this genre, a summary statement by Perrin and Winkelmann supports the importance of understanding technology by environment interactions.

> The impression from these studies is that the most pervasive explanation of why some farmers do not adopt new varieties and fertilizer while others do is that the expected increase in yield for some farmers is small or nil, while for others it is insignificant due to differences (sometimes subtle) in soils, climate, water availability, and other biological factors (Perrin and Winkelmann, p. 993).

Of course, we cannot have tunnel vision and exclude other variables that condition on-farm profitability. Regional differences in the agricultural support system, particular with regard to seed, fertilizer, and credit distribution, could strongly influence adoption. To a much more limited extent, regional diff in socioeconomic characteristics of farmers could also create disparities in regional adoption. Nevertheless, the emphasis in a late adoption study is on understanding regional differences in technology by environment interactions.

Research on late adoption contains a number of pitfalls. First-and this is a failing common to most adoption research - there is a tendency to fall prey to the "finding what you are looking for" syndrome. Adoption research on the Puebla project in Mexico epitomizes this difficulty. Researchers using different methodologies attributed the slower-than-expected adoption performance of recommended fertilizer and planting practices to a diverse set of institutional, socioeconomic, and agro-climatic constraints (Table 2). Diversity in research results spawned a heterogeneous and often conflicting array of policy implications.

Secondly, secondary data summarizing diverse aspects of regional environments are needed to construct estimates for the independent variables. This should be much less of a problem in India than in other countries.

We have started late adoption research on hybrid sorghum and hybrid pearl millet in the major producing states of India. The initial step in both studies is to construct districtwise time series profiles on rates of adoption by cultivar in the kharif and rabi seasons from 1964-65 to 1979-80. This step has been completed for Andhra Pradesh. Existing

Table 2. Specificity of theory, method, and findings in adoption research on agronomic practices to increase the production of rainfed maize in Puebla Mexico.

Researcher	Theory and method	Estimated impediment to adoption	Policy implications
Villa Issa	Human capital; Neoclassical production function	High opportunity cost of time due to off-farm employment opportunities	- -
Díaz	Institutional; descriptive analysis	Inefficiencies in the credit, extension, and crop insurance programs	Improve the efficiency of institutional programs
Moscardi	Neoclassical; Response analysis	Risk	Design technology appropriate to differing risk attitudes
Gladwin	Hierarchical decision making; Elimination by aspects	Lack of credit	Increase credit fertilizer purchase
		Lack of information	Improve plant-population communication among extension personnel
		Lack of profitability	Drop recommendation to fertilize at planting on Type A soils
Benito	Human capital; Linear programming	Uncertainty; High opportunity cost of time	Develop intermediate technologies and intermediate organizations such as solidarity groups

Source: Villa Issa, Díaz, Moscardi, Gladwin, and Benito.

intraregional diffusion studies on the adoption of sorghum and millet hybrids will also be consulted to fashion research hypotheses. Multiple regression techniques will be used to explain interdistrict variation in adoption. This research should provide a clearer picture of regional production environments for sorghum and pearl millet. It also offers ample opportunities for collaboration with state agricultural universities.

<u>Early acceptance studies</u>

Where ICRISAT like national programs has a mandate to fashion finished technologies, preadoption or early acceptance studies provide a vehicle to obtain potentially valuable information on farmers' perceptions of new technologies. Ideally, this type of short-run evaluation should follow closely on the heels of on-farm testing and should focus on cultivars and practices prior to their release as recommendations. Pragmatically, many national research programs do not have vigorous programs of on-farm testing; therefore, subjects for research on initial adoption are those farmers who demonstrate the use of the recommendation after it is released.

A random sample of these farmers who have a first hand knowledge of the prospective technology is taken and their perceptions are assessed. Criteria commonly used for the evaluation include the area planted to and the percentage of farmers adopting the technology that was tested or demonstrated in their fields in the previous year (Hildebrand, 1977). Farmer access to the technology from the first preplanting operation to the last postharvest operation is crucial for the success of any early acceptance study.

For cultivars, the main emphasis is placed on having the farmer rate the attributes of the new cultivar relative to what he has used in the recent past. A typical example of an initial acceptance study is given in Table 3 where an improved sorghum variety in El Salvador compared favorably on some agronomic traits but scored poorly on most post-harvest characteristics (Juares, 1979). For packages of practices it is important to establish a benchmark of traditional practices to fully understand the dimensions of the prospective technology. One useful way to go about this is to break the package down into its component parts and contrast each component to the farmer's present practice. For the key components, more rigorous methodologies, such as decision tree approaches, can be used to uncover farmer strategies and adoption behavior (Gladwin, 1977). As the complexity of the package increases, it becomes more important to pay more attention to institutional constraints to adoption .

These types of inquiries may not unearth substantive new findings, and for the biological scientist they may appear to be a painful rendering of the obvious, particularly if he or she was thoroughly involved in technology testing. Nevertheless, they often turn up results that were not anticipated and hence that would have gone unnoticed. They also provide firm estimates of the likelihood of success of the new technology in terms of its performance as perceived by farmers. Similar to the evaluation of late adoption, early acceptance studies are primarily oriented at biological scientists and can most effectively be carried out when biological scientists have a participatory role in them.

Table 3. Initial acceptance testing: an example comparing the perceptions of farmers on characteristics between improved and local sorghum varieties in El Salvador.

	Superior	Equal	Inferior
Germinability	50	40	10
Fertilizer responsiveness	70	25	5
Yield potential in monoculture	75	25	0
Yield potential in maize/sorghum intercrop	15	30	55
Fodder yield	10	40	50
Disease resistance	20	60	20
Midge resistance	15	75	10
Head emergence	45	45	10
Low susceptibility to bird damage	15	15	70
Ease of harvesting	65	30	5
Ease of threshing	40	30	30
Market price	5	25	70
Storage quality	15	35	50
Resistance to storage pests	20	30	50
Tortilla quality	0	35	65

Source: Juarez.

This year we will carry out early acceptance research jointly with the Farming Systems Research Program on the watershed technology tested in farmers' fields in Aurepalle, Shirapur, and Kanzara during the past two years. Contingent on its release in 1981, a candidate for early acceptance evaluation in 1982 is pearl millet cultivar WC-C75 in one or two environments where breeders feel it is best suited.

Early acceptance studies should not be an annual research event in the ICRISAT Economics Program. They depend on the stage of technology development and on the demand from biological scientists. Early acceptance research also has good potential for developing adoption methodologies useful to national program agricultural economists.

RISK RESEARCH

The Economics Program has built up an enviable record in risk-related research. Nevertheless, a number of research questions where the institute enjoys a comparative advantage have not been addressed. Risk is not easy to define, but the two graphs in Figure 3 shed some light on when risk becomes a problem. We compare net returns distributions with improved (I) and traditional (T) technologies. In the first graph, the improved technology clearly dominates the traditional and any rational farmer would choose I. In the second graph, the improved technology has both a greater variance and a higher probability of incurring losses than the traditional. Choice depends on how farmers value outcomes which is reflected in their risk attitudes. It is in the interest of society that the farmer chooses I because average net returns and production is higher with I. For risk to matter, farmers must have risk averse attitudes and perceive risky outcomes with alternative courses of action.

Risk Attitudes

Like other applied risk researchers, ICRISAT economists have directed most of their analytical attention to risk attitudes. Before Binswanger's work on risk at ICRISAT in 1977, an informal polling of economists engaged in research in the same area would have probably revealed a bimodal risk attitudinal distribution for a population of farmers in a developing country. Conventional wisdom would hold that most farmers, particularly low-income farmers, are severely averse to risk while another and not insignificant proportion, comprised mainly of large

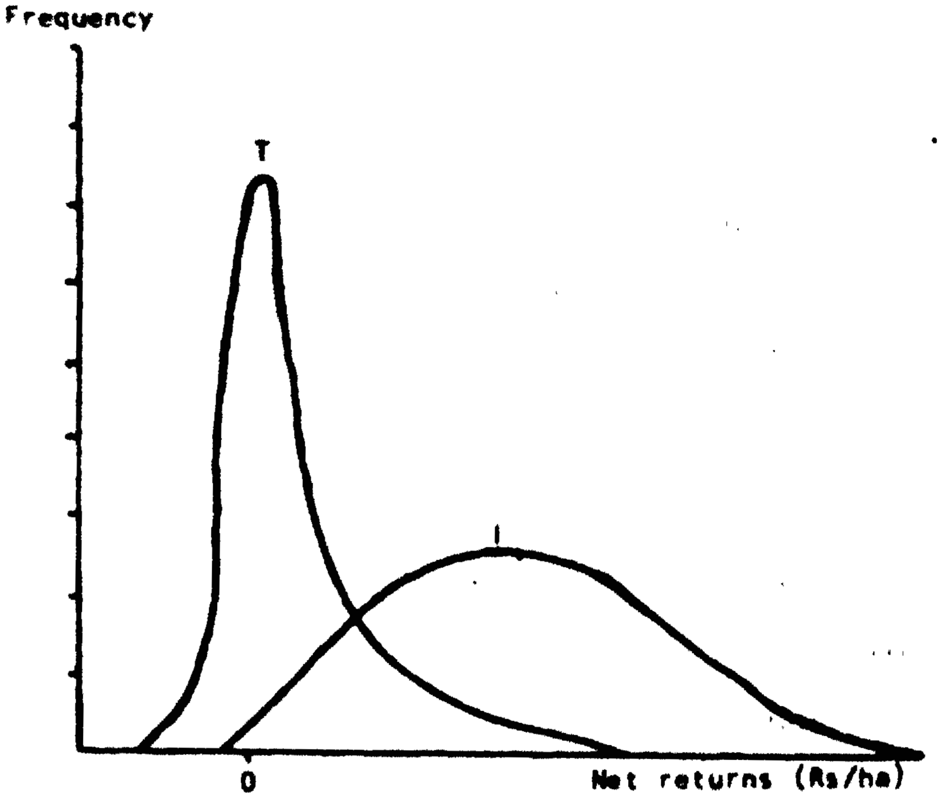

Figure 3a. No conflict between risk and expected profitability with traditional (T) and improved (I) production techniques.

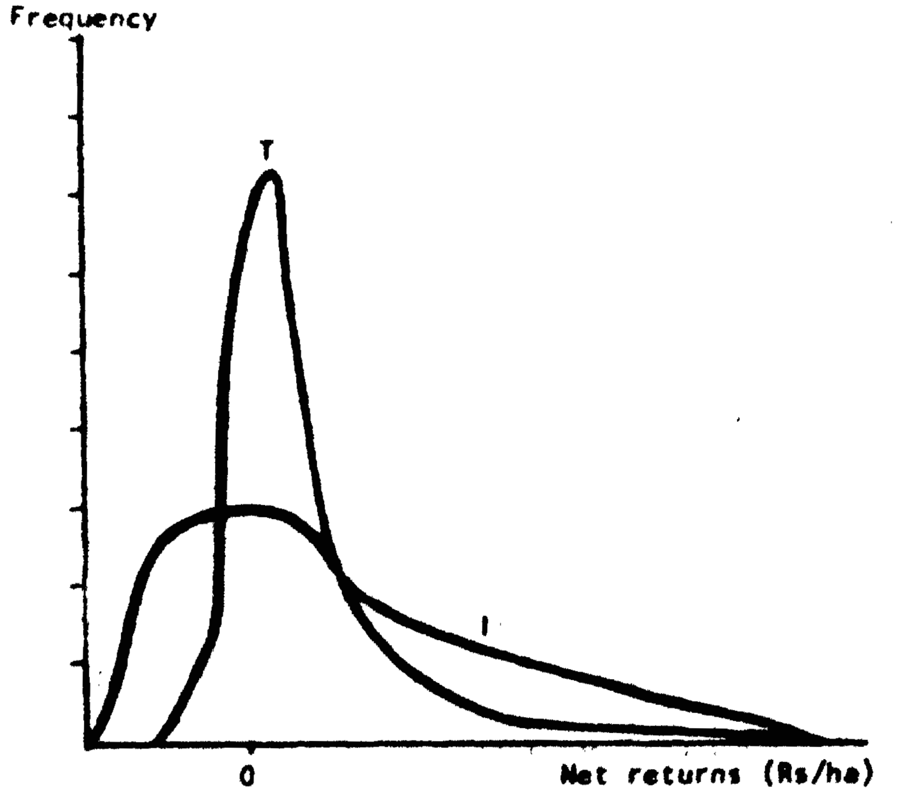

Figure 3b. Conflict between risk and expected profitability with traditional (T) and improved (I) production techniques.

farmers, are risk neutral or even display a preference for risk. This distribution would be predicted from inferences founded on measurement based on hypothetical questions and on untested hypotheses from theories of bounded rationality typified by satisfycing behavior.

Binswanger introduced experimental games to elicit risk attitudes. His results differ markedly from earlier findings. He found that the distribution of risk attitudes was unimodal as most farmers are moderately to intermediately averse to risk. Moreover, farmers chose more risk averse alternatives as the size of the games increased. The experimental method closely approximates the reality of agricultural decision making by allowing farmers time to reflect on their decisions which are also reinforced through cash payments.

The implications from Binswanger's findings (1978a, 1980) should be comforting to biological scientists. The main implication which bears repeating is that there is not a need to design and target fundamentally distinct technologies for different groups of farmers because of different preferences for risk. Estimated risk attitudes simply do not differ that much among farmers. Nor are the preferences revealed in the games highly correlated with readily measurable socio-economic characteristics such as farm size. This does not mean that farmers should not be provided a range of technological options. Nor does it imply that risk is not important. It simply means that the distributional characteristics of risk attitudes should not be an important criterion in the design of technology as is frequently maintained in the literature (Moscardi and de Janvry 1977).

The Indian experimental results are also inconsistent with many "safety-first" subsistence theories of farmer decision making. These theories would predict that farmers would choose more risky alternatives as the size of the games increases since they would be assured a higher minimum payment for opportunity losses in the larger games. The reverse occurs in the games as farmers exhibit increasing aversion to risk.

Moreover, the results call into question the validity of the optionality notion that farmers make decisions by integrating prospects into final states of wealth (Binswanger 1978b). In other words, a farmer when faced with a decision to apply fertilizer does not start from his initial wealth position say Rs. 5000/- and anticipate that with fertilizer and a favorable outcome he will enhance his net assets to Rs. 5500/- or with an unfavorable consequence his wealth position will fall to Rs. 4750/-. Rather he bases his decision on a zero starting point and thinks if he applies fertilizer and a favorable outcome occurs he will gain Rs. 500/- and if an unfavorable event obtains he will lose Rs. 250/-. At first blush the distinction in the previous two statements may seem trivial, but an evaluation on losses and gains which is supported by the experimental results switches emphasis from net asset positions to farmers' perceptions of events and consequences of following a particular course of action. The importance of subjective perceptions of risk is clearly highlighted.

Binswanger's findings for SAT India were confirmed when the same experiment was applied in the Philippines and in Central America (Table 4).

Table 4. Distribution of risk attitudes by method of measurement and country (%).

Risk attitudes by descriptive category	Method and country					
	Experimental				Interview	
	Philippines[a] 10 Peso	Philippines[a] 50 Peso	India[b] 5 Rupees	El Salvador[c] 5 Colons	Mexico[d]	El Salvador[c]
Extreme, severe risk averse	10	10	11	19	33	43
Intermediate, moderately risk averse	61	73	71	69	21	24
Risk neutral	8	12	9	5	28	14
Risk taking	20	4	9	7	18	19

[a] Constructed from Sillers (n=49)

[b] Constructed from Binswanger (n=236)

[c] Constructed from Walker (n=42)

[d] Constructed from O'Mara (n=67)

In fact, comparative results are so similar across countries that they immediately suggest two interpretations: (1) Binswanger has unearthed a fundamental feature of human behavior or (2) the results are specific to the gaming method, that is the method is the message. I prefer the first interpretation, and I also feel that application of the experimental approach with games of comparable size to other socioeconomic and agroclimatic environments like West Africa or even the United States will generate findings not significantly different from the Indian results.

If one places faith in the experimental method, Binswanger's exhaustive analysis has answered most of the questions relevant to technology policy and risk attitudes in the SAT. Most importantly, his results provide hard evidence on the level of risk to use in technology screening. His studies also marked a watershed in the empirical risk literature. More work could probably be done in considering multiple objectives of farmers with multiattribute decision analysis but early results from studies by myself and others (Herath) have not been encouraging and have not fully justified a multiattribute approach. Subsistence, bounded-rationality theories of decision making are difficult if not impossible to test empirically and are therefore not that promising for empirical research. Unless theoretical breakthoughs are forthcoming in the immediate future -- and there is no good reason to expect them because risk behavior has traditionally been one of the most heavily exploited themes in social science -- I would accord a very low priority to future work on risk attitudes.

Risk Perceptions

I am much more positive about research on risk perceptions. Not only is it a relatively unexplored applied research topic, but there is also some fairly convincing evidence (O'Mara 1971, and Walker forthcoming) that perceptions of risk overwhelm risk attitudes in conditioning the adoption of improved technologies. Risk perceptions can be looked at in two ways. An objective evaluation of risk historically tries to capture what is; subjective perceptions are what farmers actually believe "is" at a particular point in time. The Economics Program has done some work based on district-level information in the first area and has evaluated the tradeoff between yield and price risk in the SAT (Barah and Binswanger forthcoming). This research needs to be updated with farm-level information. Subjective perceptions have not been researched.

<u>An Objective Evaluation of Risk in Traditional and Improved Cropping Systems</u>

I assign the highest priority to future risk-related research at ICRISAT to improving our understanding of the distributional characteristics of yield and net return variability so that we can obtain a firmer handle on those occasions like Figure 3b when risk and expected profitability are in sharp conflict. For common cropping systems in the VLS villages, sufficient data are available to carry out an objective evaluation of financial and yield risk. With such an evaluation, we would have a much sounder base for comparing the riskiness of prospective improved technologies with traditional farming systems and for arriving at a better understanding of the agroclimatic and biological sources of risk.

From a preliminary analysis of the VLS data over the past five years, both yield and net return distributions are positively skewed and are more kurtose than normal distributions for traditional cropping systems like rabi sorghum in Shirapur (Table 5). High positive skewness and peaked kurtosis in the low-yield and low-outlay traditional rabi sorghum system favor situations where risk is likely to be an impediment to the adoption of improved technologies (Figure 4). Because so much probability mass is clustered about zero, almost any increase in outlays with new technologies will increase risk. Fodder yield tends to make the net-return distribution more normal, but it cannot compensate for the highly nonnormal tendencies of grain yield. For changes to higher-input, improved cropping systems there is fragmentary evidence (Day 1965; Barker, Gables, and Winkelmann 1980) that yield distributions shift from positive to negative skewness.

An objective appraisal of risk is a tedious analytical exercise because of its technological and site-specific nature, but it should clarify technology related aspects of risk in the SAT. Moreover, it is complementary with other projects in our research portfolio, especially the assessment of risk in a whole farm context, and has the potential for generating methodologies useful to national program scientists.

Subjective Price Risk

There are hundreds of supply response studies on how market price affects area planted to crops. More supply response studies have

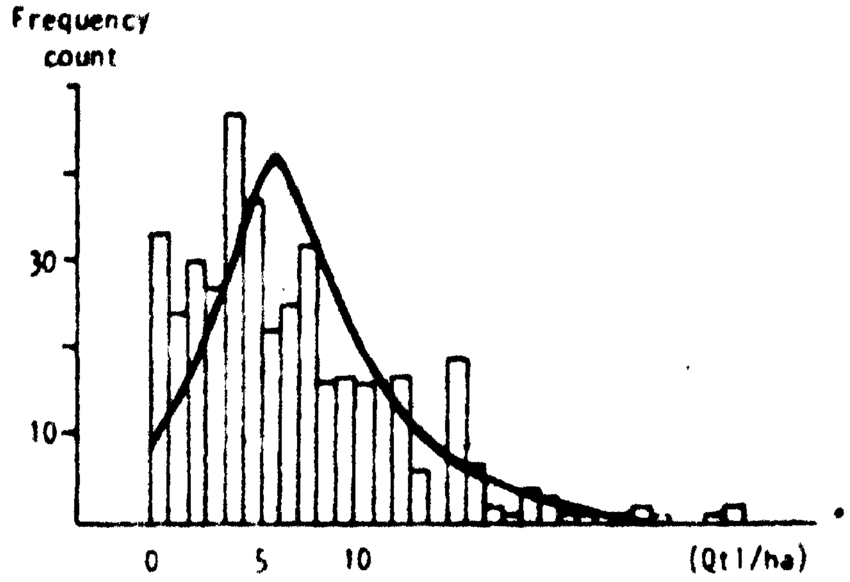

Figure 4b. Empirical fodder yield distribution for rabi sorghum in Shirapur (n = 409)

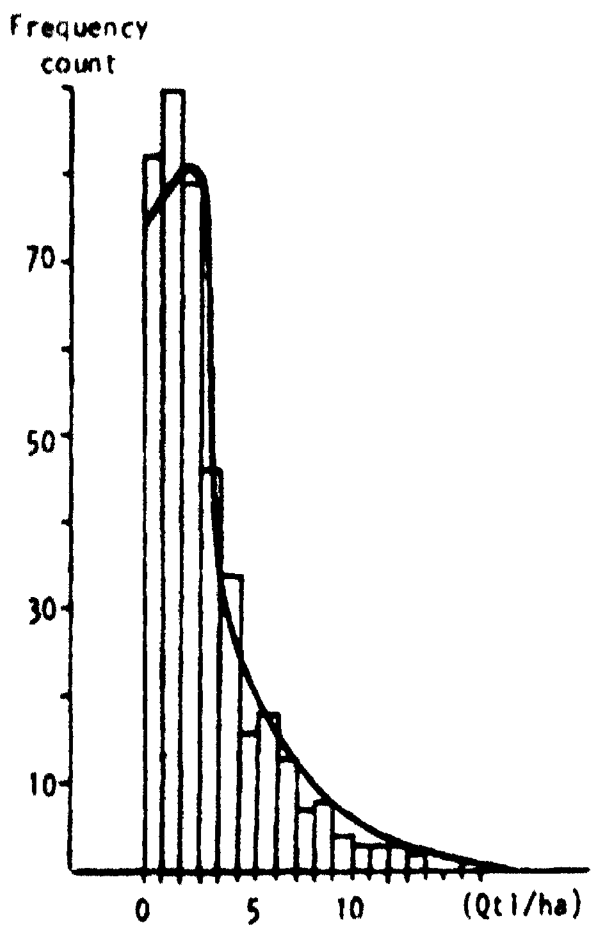

Figure 4a. Empirical grain yield distribution for rabi sorghum in Shirapur (n = 409)

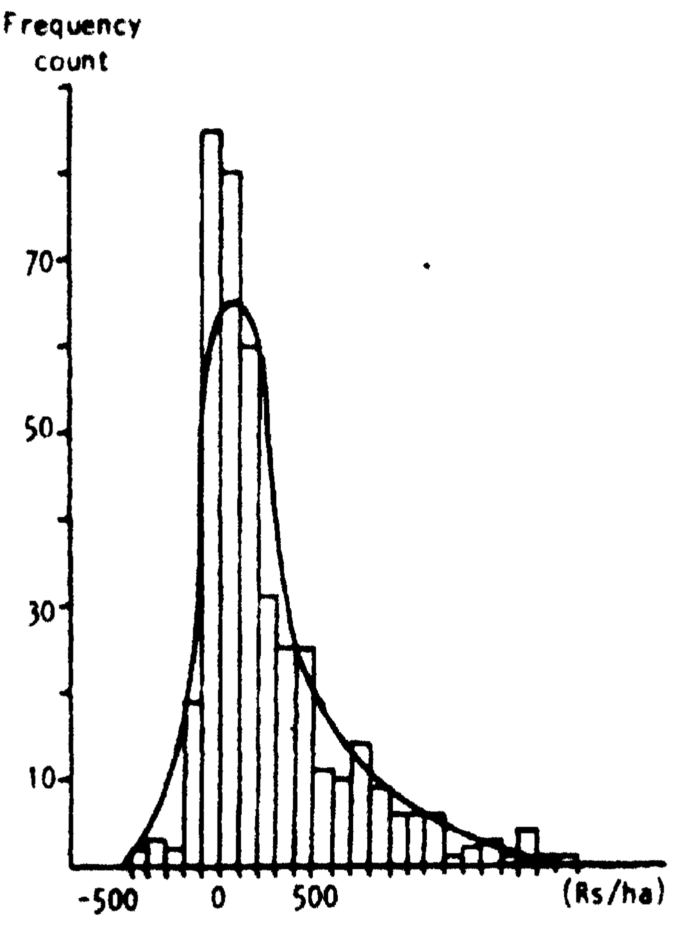

Figure 4c. Empirical net-return distribution for rabi sorghum in Shirapur (n = 409)

Table 5. Characteristics of empirical distributions for rabi sorghum in Shirapur 1975-76 to 1979-80. (n=409)

Empirical distribution	Distributional characteristics			
	Mean	Mode	Skewness	Kurtosis
Grain yield (kgs/ha)	174	46	2.96	6.31
Fodder yield (kgs/ha)	675	421	1.47	4.71
Net-returns on paid out cost (Rs/ha)	338	128	2.75	6.00
Net-returns on total cost (Rs/ha)	249	49	2.60	5.73

probably been done in India than in all the rest of the world. All these studies estimate supply relations from time-series or cross-sectional data where variation in prices occurs. All make assumptions about the decision-making behavior of farmers on what prices they expect. Most studies used last year's price or a distributed lag structure of past prices. To my knowledge only one economist (Tyagi, 1974) has ever looked at the question of how farmers form perceptions of price and how those perceptions change over time.

With the stability of the VLS collection effort, ICRISAT could have a comparative advantage on undertaking some experimental research in this area. One could ask the question why we would be interested in increasing our knowledge of price expectations for SAT farmers, particularly since we have already shown that price risk is greater in irrigated than in dryland agriculture. Two answers come to mind. First, information on subjective price risk can help us do a better job in detrending our variance and covariance data on enterprise returns in assessing prospective technologies (Young, 1981). Secondly, it could help place our market scenario analyses on a sounder footing because it will shed light on the formation of price expectations among the coarse cereals, grain legumes, and cash crops. The evidence is abundant in the Village Level Studies that ICRISAT crops compete with cash crops such as paddy, castor, and cotton. The future of coarse cereals in SAT India to some extent depends on supply and demand conditions that are translated into price expectations. How farmers form price expectations is also important to price policy questions. For example, benefits from price stabilization hinge on whether the expected covariance between price and yield is negative or positive (Hazell and Scandizzo 1977; Newbery 1980).

Subjective Yield Risk

While an objective assessment of risk may be an appealing exercise to a scientist, farmers base decisions on what they subjectively feel will happen. Research on how farmers form subjective yield perceptions over time is restricted to only one study by O'Mara 1971. Certainly more needs to be done in this area, but I am not sure that ICRISAT is the appropriate place to do it. Subjective yield risk is time, technique, and site specific and is thus an extremely difficult and messy research area. It definitely is not as clean as the analysis of price risk. Furthermore, results apply more to extension strategies and requirements for information in the diffusion of technologies. I would accord this area a low priority but a slightly higher place than research on risk attitudes.

Risk Management and Institutional Policies

Jodha's comprehensive research (1978a, b) has shown how farmers in SAT India adjust to risk. Results from his studies suggest that farmers have few adjustment mechanisms to smooth out consumption over the drought cycle without high cost and losses of productive assets, consumption credit is lacking, and public works are important sources of consumption funds for laborers and farmers during drought years.

More work could be done on the evaluation of institutional policies to diffuse risk. Crop insurance is one example where a normative feasibility analysis could be insightful. This would probably entail some historical research on the development of state crop insurance programs in India and experimental work on problems of moral hazard and adverse selection.

OTHER ASPECTS OF CONSTRAINTS ANALYSIS

Rural Credit

Access to institutional credit has been pinpointed by the program as the second most important constraint to agricultural development in SAT India. It has long been recognized that fragmented rural financial markets can frustrate economic development by denying access to productive opportunity (Adams 1977, McKinnon 1973, Gonzalez Vega 1976, and Ghatak 1976). To understand how strapped the SAT farmer is for cash or liquidity is one way to guage the existing and potential demand for credit as technology changes. The transaction data in the VLS offer a unique opportunity to quantify sources of liquidity both within and across years. Proposed research on the demand for credit will complement an on-going study by Binswanger on the supply of credit in the VLS. It will also lay a foundation for future work on investment and consumption analysis with the VLS data.

Yield Gap Analysis

Despite the high demand by agricultural research administrators for such analysis, there are no easy answers to the question of how best to conduct productivity gap research in dryland agriculture. Issues for debate range from the appropriate blend of on-farm experimentation and field observation, from the location specificity of findings over space and time, from the use of existing information relative to the collection of new data, from the type of cropping system to analyse, to who are the beneficiaries from such research.

Unless one looks at smaller diagnostic problems, a rigorous yield gap analysis is a major interdisciplinary research undertaking. Diagnostic research this year by millet physiology on cereal stand establishment in Aurepalle should provide some guidelines on the extent to which one aspect of the problem can be treated in isolation without filling in information on the larger picture.

To get started this year we are carrying out a production function analysis with five years of plotwise data for prevalent cropping systems in the Village Level Studies. This research focuses on agroclimatic and management determinants of yield and will be coordinated with similar efforts initiated this year by economists in the dryland project (AICRPDA). Our economists in West Africa are grappling with the same issues; therefore, there should be ample scope for the joint development of methodologies.

TRAINING

Up to now, training in the Economics Program has been restricted to research scholars in M.S. and Ph.D. thesis work. We recognize a growing concern to expand training to cover the in-service needs of economists working in national agricultural research programs. With the advent of farming systems research in the 1970s and accompanying changes that emphasize more farmer participation in research methodology, there are expectations that the number of agricultural economists working at national programs will continue to grow in the 1980s.

These economists can productively contribute to their agricultural research institutions by carrying out research jointly with biological scientists in the following four areas:

(1) Baseline studies and diagnostic research.

(2) Economic evaluations with partial budgeting procedures of prospective recommendations,

(3) Adoption research, particularly early acceptance studies, and

(4) Impact analysis.

The majority of these economists will not have advanced training nor will they have access to computer technology. Nevertheless, through the used of reasonably simple techniques and with the development of new methodologies and training they should be able to efficiently undertake these research tasks.

The four areas require a heavy commitment to on-farm research. Moreover, they comprise a chain of informational linkages that collectively sum to more than their component parts. Like national program economists, we have to keep an active hand in these same areas of applied agricultural research. Most importantly, we have to be able to maintain a multifaceted profile in on-farm research. Not to do so would simply mean that we will not be able to train national program economists. We would lose a vital dimension to our program.

, D.W. 1977. Policy issues and rural finance and Paper No. 1. Conference on Rural Finance Research. San Diego. July 28-August 1.

Barah, B.C. and Binswanger, H.P. 1981. The effects of crop diversification, technology, price stabilization, and crop insurance on revenue risks : an interregional analysis for India. ICRISAT Economics Program Progress Report (forthcoming), Patancheru, A.P., India.

Barker, R., Gabler, E.C., and Winkelmann, D. 1981. Long-term consequences of technological change on crop yield stability : the case for cereal grain. Pages 53-79 in Food Security for Developing Countries. Boulder, Colorado : Westview Press.

Benito, C.A. 1976. Peasants response to modernization projects in minifundio economics. American Journal of Agricultural Economics 58 : 143-51.

Binswanger, H.P. 1977. Risk attitudes of rural households in Semi-Arid Tropical India. ICRISAT Economics Program, Hyderabad, Andhra Pradesh, India.

Binswanger, H.P. 1978a. Attitudes towards risk: experimental measurement in rural India. Economic Growth Center Discussion Paper No. 285. Yale University.

Binswanger, H.P. 1978b. Attitudes towards risk: implications for economic and psychological theories of an experiment in rural India. Economic Growth Center Discussion Paper No. 286. Yale University.

Binswanger, H.P. 1980. Attitudes toward risk: experimental measurement in rural India. American Journal of Agricultural Economics. 62 : 395-407.

Day, R.H. 1965. The probability distribution of field crop yields. Journal of Farm Economics. 47 : 713-41.

Díaz, H. 1974. An institutional analysis of a rural development project: the case of Puebla project in Mexico. Ph.D. thesis, University of Wisconsin.

Gerhart, J. 1975. The diffusion of hybrid maize in Western Kenya. Ph.D. thesis, Princeton University.

Ghatak, S. 1976. Rural money markets in India. Delhi, India : MacMillan.

Gonzalez Vega, C. 1976. On the iron law of interest rate restrictions Agricultural Credit Policies in Costa Rica and in other less developed countries. Ph.D. thesis, Stanford University.

Griliches, Z. 1957. Hybrid corn: an exploration in the economics of technological change. Econometrica 25 : 501-22

Hazell, P.B.R., and P.L. Scandizzo. 1977. Farmers' expectations, risk aversion, and market equilibrium under risk. American Journal of Agricultural economics. 59 : 204-09.

Herath, H.M.G. 1980. Resource allocation by rice farmers in Sri Lanka: A decision theoretic approach. Ph.D. thesis, University of New England.

Hertford, R. and A. Schmitz. 1977. Measuring economic returns to agricultural research in resource allocation and productivity in national and international agricultural research. Eds. Arndt, Dalyrmple, and Ruttan. Minneapolis : University of Minnesota Press.

Hildebrand, P.E. 1977. Generating small-farm technology: an integrated multi-disciplinary system. Presented at the 12th West Indian Agricultural Economics Conference, Antigua, 24-30 April 1977.

Jodha, N.S. 1978a. Effectiveness of farmers' adjustment to risk. Economic and Political Weekly. 13(25) : A38-A48.

Jodha, N.S. 1978b. Role of credit in farmers' adjustment against risk in Arid and Semi-Arid Tropical areas of India. Occasional Paper 20. ICRISAT Economics Program, Hyderabad, India.

Juarez, M.A. 1979. Estudio de adopcíon de variedades mejoradas de sorgo. in Vol. 3 of Memoria XXV. Proceedings of the PCCMCA, Tegucigalpa, Honduras. Secretaria de Recursos Naturales.

McKinnon, R.I. 1973. Money and capital in economic development. Washington, D.C., U.S.A.: The Brokings Institution.

Moscardi, ER. 1976. A behavioral model for decision making under risk among small-holding farmers. Ph.D. thesis, University of California, Berkeley.

Moscardi, E.R. and A. de Janvry. 1977. Attitudes toward risk peasants: An econometric approach. American Journal of Agricultural Economics. 59 : 710-16.

Newbery, DG. 1979. Institutional response to the existence of agricultural risk : an introduction. pp. 279-282. Risk, uncertainty, and Agricultural Development, eds. Roumasset, Boussard, and Singh. SEARCA and the Agricultural Development Council, Laguna, Philippines and New York.

O'Mara, G.T. 1971. A decision theoretic view of the microeconomics of technique diffusion. Ph.D. thesis, Stanford University.

Perrin, R.K. and D.L. Winkelmann. 1976. Impediments to technical progress on small versus large frams. American Journal of Agricultural 58 : 888-94.

, J.A. 1976. Rice and risk : decision making among l farmers. : North Holland.

Sillers, D.A. 1980. Measuring risk preferences of rice farmers in Naeva Ecija, Philippines : An experimental approach. Ph.D. thesis, Yale University.

Slade, R. and Feder, G. 1981. The impact of agricultural extension. A case study of the training and visit method in HAryana, India. Washington : World Bank.

Tyagi, D.S. 1974. Farmers' respond to agricultural prices in India. Delhi : Heritage Publishers.

Villa Issa, M. 1976. The effect of the labor market in the adoption of new production technology in a rural development project : the case of plan Puebla, Mexico. Ph.D. thesis, Purdue University.

Walker, T.S. 1980. Decision making by farmers and by the national agricultural research program on the adoption and development of maize varieties in El Salvador. Ph.D. thesis, Stanford University.

Walker, T.S. 1981. Risk and adoption of hybrid maize in El Salvador. Food Research Institute Studies (forthcoming), Stanford University.

Young, D.L. 1981. Measurement of objective probabilities from the series data. Presented at 1981 W-149 Annual Meetings, San Diego, CA, January 6-8, 1981.

ACKNOWLEDGEMENTS

I am grateful to participants who helped shape my ideas during two program seminars held earlier in the year. I thank Jim Ryan for his comments on this paper. I also thank Hans Binswanger for leaving me a large pair of shoes to fill and all staff who have made the Economics Program what it is today.