AN EVALUATION OF RISK AND UNCERTAINTY RESEARCH IN RELATION TO CROP VARIETAL DEVELOPMENT

By

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ABBREVIATIONS

ICARDA	The International Center for Agriculture Research in Dry Areas (Syria)
ICRISAT	The International Crops Research Institute for the Semi-Arid Tropics (India)
IRRI	The International Rice Research Institute (Philippines)
AZRI	Arid Zone Research Institute (Quetta, Pakistan)

CHAPTER I

INTRODUCTION

Agriculture development efforts in the past have focused heavily on increasing aggregate output in less developed countries (LDC). In the last 2-3 decades technology served as a key policy instrument used by developed countries to aid the less developed ones. However, such a policy had lead to the neglect of certain farming groups, particularly small farmers. Recent trends in agriculture development tend to pay special attention to the needs of small farmers. It is the small farmers who form the backbone of agriculture in many LDC's. As their development receives priority, so does the need to gain a better understanding of their farming needs.

Small farmer response to technology has been unevenly distributed. This has not only varied amongst the LDC's, but technology adoption rates differ within countries. Besides many socio-economic constraints experts consider risk and uncertainty to play a dominant role in technology adoption. The major issue is to what extent should risk and uncertainty be taken into account while evaluating potential technology. Farmers in many developing countries have shown preference for traditional technology over the improved one.

The discussion of this paper focuses on the decision making strategies of farmers. Particularly those strategies adopted in choice of varieties and allocation of resources to agriculture. Our interest is to see what extent does risk and uncertainty enter the farmer decision process. The focus here is not limited to the small farmers alone, however, they are of special interest in this paper. Usually a small farmer is taken to be synonymous with a poor farmer, but farm size alone is an inadequate criteria for distinguishing a poor farmer from those that are better off. Net per capita income appears to be a better proxy by which to define small farmers, Singh [1]. According to Singh amongst the many characteristics of small farmers, the following are commonly agreed upon.

1. Low proportion of output marketed, a high proportion retained for home consumption.
2. A high proportion of land devoted to food crops.
3. A more diverse crop portfolio.
4. Greater aversion to risk.
5. A greater scarcity of cash and capital resources.
6. More abundant labor then on larger farms.

These and many other characteristics distinguish small farmers from other groups. Many times tenants, sharecroppers and landless laborers have been included in this category. For the purpose of this study a small farmer will be considered one with a low per capita income.

Objectives of the Study

This paper will deal with the decision making aspects of small farmers. Particular emphasis is on the choice of technology, (with emphasis on varieties) under conditions of risk. We are interested in gaining insight into variables which effect farmer decision making.

The more specific objectives of this paper are two-fold.

1. To review literature on risk and uncertainty research related to varietal evaluation.
2. To identify important variables which influence the farmer decision making process in choice of technology (with particular focus on varieties).

Risk and Uncertainty

At present there is much debate amongst theoreticians and applied researchers on research issues related to risk and uncertainty. Before proceeding further it appears appropriate to define risk and uncertainty.

Risk and uncertainty have been defined differently depending on the purpose in mind and the research needs. Although there is agreement on the general connotation it carries, still it is important to note how different authorities on the subject distinguish between risk and uncertainty. Frank Knight [2] distinguishes between risk and uncertainty in the following manner.

1. Risk is a condition where probabilities of outcomes is known.
2. Uncertainty is a condition where probabilities associated with an outcome are not known.

Roumasset [3] views this difference as:

1. Uncertainty is a state of mind in which the individual perceive-alternatives to a particular action.
2. Risk on the other has to do with degree of uncertainty in a given situation.

A plausible question is when is an action with outcomes described by a probability function[1/] "riskier" than an alternative choice. Rothshied and Stiglitz [4] offer three equivalent definitions:

1. Let x and y be two random variables with distribution F and G. We define y to be riskier if every risk averse decision maker prefers x to y

$$EU(x) \geq EU(y) \text{ for all concave U functions.}$$

2. Assume y has more weight in the tails then x or if distribution g was obtained from f by taking some of the probability weight from the center and adding it to each tail of f so as to leave the mean unchanged

$$\int_{-D}^{y} F(x)\, dx > \int_{-D}^{y} G(x)\, dx \text{ for all } y.$$

3. y is equal to x plus noise. If we add some uncorrelated noise Z to a random variables, the new variable should be riskier than the original. Let y = x+Z where y and x have the same distribution and E(Z/x) = 0.

Barry [5] uses uncertainty to indicate incomplete knowledge on the part of the actor and defines "risk" as the possibility of incurring a loss of production activity.

[1/] A probability density function is the first derivative of the cumulative density function (CDF). Assume a random variable μ that can vary continuously from μ=a to μ=b. The function P(μ) is such that $\int_a^b P(\mu)\, d\mu = 1$. That is the sum of the probabilities is a equal to a unity. The CDF is given as $\int_{\mu}^{\mu_o} P(\mu)\, d\mu$. It is the probability that μ will be smaller than or equal to the value μ_o which is $\leq$ b [3].

The definition forwarded by Frank Knight is followed in this paper. However, it is slightly modified in the sense that we make an explicit assumption that farmers do formulate subjective probability distributions and the course of action they follow depends on the expected returns of these distributions.

The area of decision making research is progressing very rapidly. Most of this research is focused on strengthening the foundations of the modern decision theory. However, a question which is often debated is that of the relevance of research on risk and uncertainty. Binswanger [6] provides several reasons as to why we should be concerned with empirical risk and uncertainty research. They are as follows.

1. Risk and uncertainty affect the efficiencies of production and investment decisions by individual firms and government.
2. Risk and uncertainty affect the distribution of income and wealth among households.
3. Risk and uncertainty affect policy prescriptions and effectiveness of policy tools.

Attitude towards risk and uncertainty are important in directing the agriculture development process. Both risk and uncertainty influence variables which set the pace for development. A breakdown of various reasons why we should be concerned with farmers attitudes towards risk and uncertainty is shown in Table 1. Our interest in this paper lies in concerns one and four; which focus on agriculture research strategy and technology adoption. We want to know how technology can be modified in a risky and uncertain environment, so as to be more acceptable, particularly among small farmers.

TABLE 1. Reasons to be Concerned About Attitude Towards Risk of Various Actors in the Development Process

Concerns	Actors Whose Attitude Towards Risk are Involved
1) Adoption of profitable but risky technology by farmers (with emphasis on efficiency implication)	Farmers Money lenders Credit institutions
2) Income-distribution implications of differential risk aversion and its implication for crop choice, adoption behavior, and credit use (who will grow/survive in a dynamic environment)	Farmers Money lenders Credit institutions
3) Regional planning and investment strategies, e.g. whether to concentrate investment on high-potential/low risk regions or not	Policy makers Administrators Donor agencies
4) Agricultural research strategy, e.g. on which regions to concentrate research investment, or what emphasis to give on stability of technology as against productivity	Farmers Researchers Research Administrators
5) Attitude towards risk as determinants of rural institutions (e.g. share cropping)	Farmers/Landowners Laborers (Potential share croppers) Leaseholders
6) Take account of attitudes towards risk in output supply analysis	Farmers
7) Increase utility by reducing fluctuations in outputs, prices, and incomes (price and output stabilization	Farmers Consumers Government

Source: Binswanger, H. P., "Risk and Uncertainty," Agricultural Development. Notes on an ADC Seminar, Occasional paper, 17, ICRISAT, India, 1977.

The paper is organized as follows. Chapter two provides a literature review related to risk and uncertainty, which will help to identify objectives for outlining a proposal. This proposal outline is presented in the appendix. In chapter three two approaches to varietal evaluation are discussed. Both approaches take into account farmer risk preferences in choice of varieties. Chapter four provides an illustration of variables affecting decision making in barley production. In this regard some data from Syria are presented. This is followed by a brief summary and closing statement.

CHAPTER II

RISK AND UNCERTAINTY RESEARCH IN RELATION TO FARMER DECISION MAKING: A LITERATURE REVIEW

In this section a review of research on risk and uncertainty is carried to identify a few approaches for detailed examination. The literature reviewed in this chapter is related to those aspects of risk and uncertainty which have a bearing on the production decisions of farmers. Over the last decade many attempts have been made to gain a better understanding of the decisions related to farm production.

It was stated earlier that uncertainty is related to unpredictable outcomes. Rochin [7] points out that:

> "Sources of uncertainty relate to variations in expected yields, availability of complementary inputs and market prices. Increased dependence on market for inputs and sales add to uncertainty and risk. The lack of stability (and credibility) of government support programs for small farmers can be a constraint on the decision to adopt or undertake an uncertain action."

This suggests the importance of government support programs (input subsidies, quotas, price support) in removing future uncertainty. Small farmers particularly often hesitate to take the initiative of adopting technology, even in the presence of government support policies. Schutjer [8] argues that:

> "In many cases, it is not the low income of farmers which holds them back from adopting technology or management practices. But it may be the instability of the expected returns which threaten the very existence of the farmer and his family."

In many LDC's the main constraint governing the use of inputs is often scarce liquidity. Ryan et al. [9] in a study on India conclude that:

> "Many farmers in less developed countries are constrained by internal and/or external capital rationing, then the return per unit of that limited capital becomes an extremely important criterion governing decisions. Returns per hectare of land can be less relevant in decisions under these circumstances. In most instances it is small farmers who are faced with this type of constant."

Hence constraints physical and biological, and economic play a dominant role in determining the course of action taken by a farmer.

Recently more attention is being given to modeling farmer behavior under conditions of risk. However, these attempts have not been fruitful as indicated later in the paper. Mind experiments and direct utility measurement have been widely applied as well as numerous mathematical models to estimate farmer attitudes towards risk.

Dillon and Scandizzo [10] used mind experiments between risky and sure farm income alternatives. In the first set of experiments the farmers total income was uncertain, but his subsistence need was assured. In the second set subsistence requirements was also at risk. They found that subsistence farmers are more risk averse and risk aversion tends to be more common among small owners then sharecroppers. They point out that other variables as income, farmers age and ethical attitudes towards betting may influence their behavior in choosing among risky prospects. This viewpoint is also supported by Nygaard and Roe [11]. They studied the risk behavior of Tunisian wheat farmers in choosing among traditional and high yielding varieties. In this case the experience variable was considered important in farmers choice amongst varieties. A detailed review of their model is presented in the next chapter.

Anthropologists working with decision analysis have often noted the importance of ethical attitudes (i.e., religion, caste, ethnic origin) as determinants of farmer risk preferences. For example in fundamentalist moslem societies expectations regarding future outcoms (states) are considered predetermined. Many view it religiously improper to make guesses, as to what will happen in the future. This suggests that farmers holding such beliefs may prefer not to reveal their expectations concerning likelihood estimates for unfavorable acts of God and is not to imply that they are void of subjective density functions.

A study conducted by Binswanger [12] in India using mind experiments provides quite different insights. His extensive experience with risk and uncertainty research lead him to the following conclusion:

> "Differences in investment behavior observed among farmers facing similar technologies and risk cannot be explained by differences in their attitudes, but would have to be explained by differences in their constraint sets."

These conclusions certainly highlight the importance of studying farmer constraints.

There have been numerous studies conducted to show the economic rationality of farmers. It is now well established that farmers attempt to allocate resources in an optimal manner, equating the marginal productivity of inputs to their respective prices, Shultz [13], Yotopoulus and Nugent [14]. However, this efficiency criteria becomes difficult to implement under conditions of uncertainty in dryland agriculture. Under dryland conditions as in all farming conditions farmers show adaptive behavior, Day and Singh [15]. These authors have outlined a micro-economic theory which takes into account the adaptive nature of farmers when confronted with a decision. They criticize the simple neo-classical model by stating that:

> "...Unfortunately this neoclassical model underplays the complexity of technology; it overplays the complexity of perfect knowledge of farmers and exaggerates the efficiency of markets."

This would mean that in understanding farmer decision making under conditions of risk and uncertainty we need to study the dynamic strategies followed by farmers. This may result in violation of not only certain neoclassical assumptions but also in the results expected under competitive conditions.

Over the past decade or two there has been heavy emphasis on the application of Baysian probability theorm in agriculture decision processes. The proponents of this approach have severely attacked classical production economic theory on the basis that it ignores the stochastic nature of agriculture production, Anderson et al. [16]. More severe has been the attack on simple profit maximization criteria. Lin et al., [17] provide evidence that Bernoullian utility maximization criteria explains actual farmer behavior better than profit maximization. Utility maximization is more attractive than profit maximization in that: (1) it can explain why two individuals faced with exactly the same situation might rationally respond quite differently; and (2) utility maximization does not exclude profit maximization but rather includes it as a special case of Bernoullian utility.

A more recent approach as the one illustrated in the next chapter involves the elicitation of preferences and subjective probabilities through farmer interviews. Although such indirect measurement of farmer revealed production functions do not guarantee that the same parameters are valid for decisions actually made by the farmer. Nevertheless, such an approach does help to identify variables which effect the outcomes of a decision, Petit [18].

Learning and experience both have a bearing on the decision making process. Hiebert [19] in a study on fertilizer and variety adoption interprets learning to mean gaining more information about the probability distribution of output which reduces the possibility of allocative error. He states that one reason for allocative error is that producers are mistaken about the true value of certain parameters of the production function. He further adds that "a natural interpretation of learning is gaining additional information about the unknown parameters; which reduce the likelihood of allocative mistakes." This would imply that as a producer gains additional information about the unknown parameters, he will adjust his level of input so that possibilities are redistributed from a lower payoff matrix to a higher one. Then a hypothesis which follows is that under extreme environmental conditions an allocative mistake commited in input use results in serious consequences and threatens the existence of a small farmer. Farmers in risky agriculture environments will tend to be more conservative about their input/output estimates (parameters). These low conservative estimates may not provide enough justification to experiment with new technology.

Design of successful technology involves pre-testing before it is finally promoted for use on a large scale. Recently the need to screen agriculture technology (particularly high yielding varieties) for risk and uncertainty has been undertaken to some extent. The next chapter illustrates a generalized regression approach which is being employed by two International Research Organizations. IRRI (International Rice Research Institute) in the Philippines and ICRISAT in India. This approach is guided by the assumption that farmers prefer varieties which have a low variance and adaptability.

A wider framework for analysis of small farmer decisions has been provided by Gladwin [20]. Her model provides a simplified version of real life decision making. Her theory differs from the economists approach because it does not assume that decision makers can rank all available alternatives on preference or indifference maps. Instead, she suggests a psychologically more realistic two stage model of the choice process, that may be represented by a decision tree, a table or a set of rules.

Gladwin's approach proceeds by an elimination process linking each aspect of a decision process to a constraint or alternative. Only after arriving at a final decision does she suggest any maximization technique. Her approach has certain merits. Firstly, it gives a better framework to answer questions as to why or why not a certain act was not carried out. Secondly, it provides a sequential analysis of all constraints which affected the final decision. Her approach differs from the modern expectation model, which only considers risk, she also takes into account the decision process.

Reviewing the literature indicates that understanding the impact of risk and uncertainty on the production decisions is very important. It also becomes evident that approaches which study risk through mind experiments and expected utility approach fail to provide information which can be helpful in formulating policy prescriptions. This is due to the fact that a sampling approach involving any of these techniques cannot be generalized to the region and secondly that most of these techniques provide estimates which show whether a farmer (or group) of farmers are risk averse, neutral or risk loving. These results are not very useful for the purpose of problem solving. What is more important is to gain insight into the constraints which are responsible for farmer decisions. As suggested by Binswanger often it is a socioeconomic or biological constraint which holds back farmers from adopting technology and therefore needs to be identified to understand the different decision making strategies employed by farmers. This will require taking a broad approach to identify information relevant to the design of future technology. The knowledge gained will also provide guidelines for directing government policy aimed at evaluating critical constraints faced by farmers.

CHAPTER III

TWO PROMISING APPROACHES TO AID IN EVALUATION OF RISK AND UNCERTAINTY VARIABLES AFFECTING FARMERS DECISIONS

This chapter examines two promising approaches to varietal evaluation identified by the review of literature. Both these approaches represent distinct methodologies for incorporating attitudes towards risk in choice of varieties.

The material presented in this chapter draws heavily on the following studies of Roe and Nygaard [11], Binswanger and Barah [21] and Evenson et al. [22].

I. An Allocative Error Approach

The work by Roe and Nygaard deals with understanding the factors influencing resource use in growing durum wheat in Northern Tunisia. This work was based on studies by Moscardi, de Janvry, Wolgin and Binswanger who have focused on the efficiency of resource allocation and factors influencing allocative efficiency. Their approach integrates in a single theoretical framework the effects of both risk and farmers knowledge of production on the overall efficiency of resource use.

The specific objectives of this study were:

1. To obtain knowledge of production function for both ordinary and high yielding varieties.

2. To explain how farmer knowledge affects the resource allocation errors they make in producing durum wheat.
3. To ascertain farmer risk attitudes and whether they perceive high yielding varieties to be riskier to produce then ordinary varieties.
4. Whether risk attitudes affect resource use and to obtain insights into the factors associated with these attitudes.

Data for this study was collected by Nygaard as a part of his Ph.D. thesis. The final sample comprises of 125 durum wheat producers. HYU's were planted on 128 parcels, while 100 parcels were planted ordinary wheat.

Theoretical Framework

In deriving risk parameters each producer is assumed to be a mean-variance expected utility maximizer with E(U) of gains and loss (Π_n) incurred in the production of durum wheat given as

$$E(U_n) = U(E[\Pi_n], V[\Pi_n])$$

Expected profit $E(\Pi_u)$ is mathematically represented as:

$$E(\Pi_u) = P.E(y_n^P) - \Sigma_k^{k*} = 1^{P_k X_{kn}})$$

P = price of durum wheat

$P_{k,\ n}$ = price of nitrogen and phosphorus respectively

X_{kn} = inputs, fertilizer and machinery

k = 1, 2, 3

The utility maximization procedures were of the standard form using calculus techniques.

Two sets of production functions were fitted. The first set of functions were the true or realized production functions; while the second set was called the subjective production function, based on yield expectations at the time of seed bed preparation. In order to fit both these functions, data was collected both for ordinary and HYV's. The objective was to compare the true production function with the expected estimated errors committed in resource allocation.

The mathematical forms of the true production functions used were:

$$(1)\quad Y^t_{HV} = B_1\ Ph_1^{\beta_1}\ N_1^{\beta_2}\ M_1^{\beta_3}\ L_1^{\beta_4}\ e^{\beta_6 D_2 + \beta_7 D_3}$$

$$\varepsilon_1 = f(X_1;\ \beta)\varepsilon_1$$

$$(2)\quad Y^t_{OV} = B_2\ Ph_2^{\lambda_1}\ N_2^{\lambda_2}\ M_2^{\lambda_3}\ L_2^{\lambda_4}\ e^{\lambda_6 D_2 + \lambda_7 D_3}$$

$$\varepsilon = f(X_2;\ \lambda)\varepsilon_2$$

where Y^t_{HV}, Y^t_{OV} = Quintals of durum wheat harvested.

Yield is a dependent variable and Ph (phosphorus), N (nitrogen), M (expenditure on field operations) and L (hectares of land in parcels) are the variable inputs. The parameters are B. β, λ and ε a stochastic term. The dummies D_2 and D_3 capture the soil type and zone variability.

For the second set of production functions, they assumed that each producer formulates subjective density parameters. Now if we interpret this statement as the farmers subjective estimates of the physical productivity for inputs, then the question arises how much faith can one entrust to such estimates.

The two specifications for the subjective production function are of the same form presented earlier for true production functions, and differ only by one additional variable (EX) which is an inverse of farmers years of experience. For the subjective production functions A*, β* and λ* are the parameter and v is the stochastic term.

Now if the realized and subjective production function differ (for HYV's and ordinary varieties), then the farmer has probably committed an allocative error. This means that he has allocated his inputs in a nonoptimum manner which does not result in a least cost combination. In other words, the following equality does not hold.

$$\frac{MPPx_1}{Px_1} = \frac{MPPx_2}{Px_2}$$

If this equation holds, optimum allocation has been achieved. One of the hypothesis forwarded is that as farmers experience with growing HYV's increases, eventually the $A_1EX^{\beta_5^*}$ and $A_2EX^{\lambda_5^*}$ where A_1, A_2 = constants and EX = inverse years of experience, will approach the β_1 and β_2 values of the true production functions.

In other words, farmers will not make any errors in resource allocation in the long run. However, one would hesitate to accept this hypothesis for making broader generalization in other countries i.e., Pakistan, Turkey, India, etc. because in some areas varietal run off and poor disease resistance performance of recent variaties has often led even experienced farmer to commit large errors, Muhammed, 1979 [23].

The analysis involved estimates by ordinary least squares (OLS). The coefficients explained 77 and 79 percent variability respectively for HYV (true) and ordinary varieties at harvest. The possibility of interdependence amongst the variables may have biased the results. For a partial cure of this problem they suggest that the addition of a dummy variable (D), to account for weather, zone and soil differences, this should eliminate part of the bias. They administered a chow test for structural differences of HYV's and ordinary varieties. On an individual basis, this test suggests that neither the phosphorus (Ph) nor the nitrogen (N) coefficients are significantly different from an earlier study done by Saleem Gasfi in 1972/73. When the estimates were compared to Gasfi's study there was positive correlation between size of holding and HYV's. As parcel size increases yield may tend to increase as a result of better management.

The regression results of the subjective production function included four different formulations. Before making any comments on these regressions it is important to note that because both the slope parameters (β_1^* and λ_1^*) in the equations for ordinary and HYV's subjective functions were not significantly different they were combined to fit the data.

The resultant combined model was:

$$Y = A\ Ph^{\beta_1 o} + N^{\beta_2 o}\ M^{\beta_3 o}\ L^{\beta_4 o}\ EX^{\beta_5 o}\ e^{\beta_6 o}\ D_1 + D_2 + D_3$$

$$V^o = f(X,\ EX;\ \beta^o)V^o$$

In one of the regression equations, a negative sign appears with the experience variable.

Their interpretation is that as farmers experience increases, higher yields can be expected; however, the increase in the yields tends to decrease with each additional year. Moreover small farmer yields tend to decline after some time due to seed degradation unless improved hybrids are continually made available.

In comparing the data with an earlier study conducted by Saleem Gasfi in 1972/73 it became apparent that weather played an important role in determining the size of an allocative user with regard to HYV's. A "t" test suggested that had 1976/77 been a normal year, the farmers perceptions of the productivity of P and N fertilizer would not have been a source of error. A similar conclusion was obtained by comparing the constant terms.

In order to derive a measure for allocative error an estimate perceived average cost figure was compared with the realized or true average costs. A function fitted on basis of the least cost combination principle suggested that at the time of seed bed preparation the farmer expected an average/quintal cost of fertilizer and machinery allocated to the production of HYV to be 2.72 dinars and 3.28 dinars for ordinary varieties. In other words the expected cost in fertilizer and machinery was 21% higher. However, since farmers expected 30% more yield from HYV's as compared to ordinary varieties they allocated more resources to HYV's.

In order to explain the difference amongst allocative errors, they defined a new variable

$$E = \frac{CP/YP}{CT/YT}$$

(where P and T represent perceived and true values), which was regressed as a logarithm of this variable on cognitive and other informational variables. Two important results become apparent. Firstly, that increase in experience (i.e., cognitive skills) tended to lower error and secondly that farmers in high rainfall areas tended to commit larger errors than ones in low rainfall areas. A plausible explanation for this is that input use in high rainfall areas far exceeds that in low rainfall areas. Moreover, expected returns to experimenting with new technology are higher where there is some certainty of rainfall; hence chances of committing allocative mistakes are also greater.

The authors state that 75 percent of the farmers were risk averse and applied a subjective discount rate due to risk. However if the impact of risk were completely eliminated, there would be yield increases in the range of 4.7% for ordinary varieties to 15% for HYV's if perfect weather conditions prevailed.

With respect to policy recommendations they conclude that technology packages and farm level programs should not discourage the use of ordinary varieties. Another interpretation would be that breeding programs should lay more emphasis on improving indigenous wheat varieties while maintaining certain desired local characteristics such as drough resistance, cooking quality and color, etc.

This study by Roe and Nygaard provides an effective framework for evaluating farmer attitudes towards new and old varieties in an expected utility context. Moreover, from a practical viewpoint, this research shows that farmers can be grouped on basis of different criteria i.e., size of holding wealth, education, etc. so as to access their technology requirements within their constrained sets. The overall lesson to be learned from the Tunisian research is that whatever the farmers response to technology may be, cognitive variables play a critical role in allocating resources to different varieties.

II. Multiple Regression Approach to Evaluating Experimental Results

This section examines an approach used to evaluate varietal trial data for yield stability, adaptability and degree of risk. The material in this section draws on two studies done at IRRI in the Philippines and ICRISAT in India. These studies illustrate the incorporation of risk and uncertainty for varietal breeding.

Binswanger and Barah [21] have discussed several methods of stability and adaptability analysis. For risk analysis they measure stability by the tradeoff between standard deviation and the mean. These researchers point out that environmental variability within a given location poses problems to the producer, while variability across locations does not cause risk or uncertainty to producers, however it does have implications for crop improvement research. Firstly, varieties are bred for a specific region and a set of characteristics. Secondly for a particular producer, the concern is whether the variety is stable under his conditions not whether it shows stability over the whole region. On the other hand the breeder is concerned with the overall stability of a genotype.

Before proceeding further two concepts are defined, which will be used later.

1. Adaptability of the Genotype: A genotype is adaptable if its average yield over a year at a given location varies little across locations. Evenson defines adaptability as the performance of a genotype with respect to environmental factors that change across locations.

2. Stability of the Genotype: Refers to the performance of a genotype with respect to changing environmental factors over time at a given location.

Of these concepts the stability of a genotype is obviously more important for a producer. However, it becomes a rather narrow breeding objective to breed for stability alone without incorporating adapatability, as the breeder is interested in minimizing risk over a spectrum of locations.

Optimization in Crop Improvement Research

Evenson et al. [22] provide an excellent illustration of the application of micro-economic principles to agronomy and plant breeding research. A key concept used is that of the search principle which states for a given set of resources (i.e., genetic material), the plant breeders objective is to maximize the selection of the most efficient set of genotypes subject to a constraint i.e., minimum yield, etc.

Mathematically expressed as:

$$F(X) = \lambda e^{-(X-\emptyset)},\ \emptyset \leq n$$

where the distribution is a simple exponential with mean O. For the above 'distribution' the expected value of X denoted as Z in a sample of N searches can be written as:

$$E_u(Z) = \emptyset + \frac{1}{\lambda} \sum_{i=1}^{n} \frac{1}{i}$$

The above equation suggests that X rises with N, but at a diminishing rate. Evenson notes that this property holds for all distributions. Another application illustrated by him is the breakeven point for conducting research. A basic optimization rule in economics states that investment should be carried up to a point where marginal returns equal the marginal cost (see Figure 1). In other words, search for an efficient genotype should be continued as long as MC of the research is less or equal to the expected returns. It is rather difficult to determine a saddle point where the potential search of a particular genotype would exceed cost of search. The decision which a breeder has to make is whether to entirely replace the genetic stock at hand or to add new material. This suggests shifting to a different production function when MC $\geq$ MR for genetic material in use.

Screening Varieties Under Conditions of Risk

Plant breeders often use different statistical techniques (i.e., analysis of variance, correlation analysis, plot design, etc.) in screening varieties. However, the use of multiple regression has been rather limited. This tool has been employed more extensively by economists assisting in evaluating potential varieties. Numerous econometric models are formulated to understand the important eco-biological relationships. Binswanger [21] suggests that the most general form of these models is:

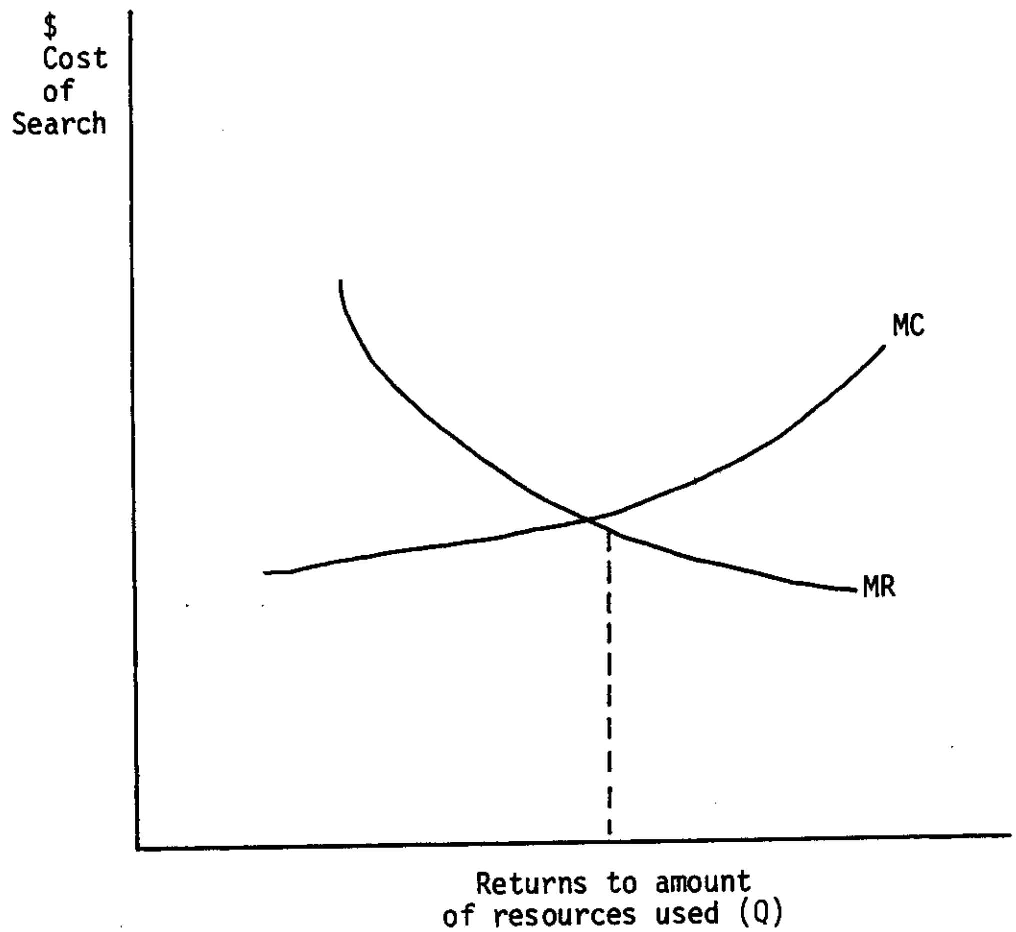
$$Y_{ij} = \mu_1 + \sum_{n=1}^{H} B_1^h E_j^h + \gamma^*_{ij}$$

where

Y_{ij} = yield of genotype i in environment j

E_j = deviations of the environmental variable from their mean across the location

γ^*_{ij} = residual into genotype interation



Breakeven Point for Conducting Research

FIGURE 1

$h = 1, \ldots H$ = index for plant independent variables

Binswanger also considers a specific case

$$Y_{ij} = \mu_1 \beta^{c}_{1cj} + \beta^{Z}_{12j} + \beta^{W}_{1wj} + Y^{*}_{ij}$$

in the above regression. It includes the following three types of plant independent variables. They are:

c = control variable, i.e., fertilizer, insecticide, etc.

z = site variables, i.e., soil type, topography

w = weather variables which vary from year to year

From a stability point of view the weather is the most important variable. In an uncertain environment a value close to zero for the weather variable (w) would imply stability. Moreover, for evaluating a cultivar for a particular region the value of the site variable close to zero would be most desirable. However, the coefficient of β^{c}_{1} which carries the control variables like fertilizer, seed and pesticide should have higher values in order to explain responsiveness to these inputs. Low values of β^{Z}_{1} and β^{W}_{1} are desired so as to minimize variability. Low values of β^{Z}_{1} and β^{W}_{1} are desired so as to minimize variability. If β^{W}_{1} and β^{Z}_{1} have low values the true productivity of the control inputs would show up in the regression.

In conclusion, low coefficients of weather and location show high degree of stability. Hence, genotypes which possess this characteristic would be preferred by a risk averse farmer. An important point to note while conducting multiple regression is the invalidity of the traditional statistic R^2 (which explains the total variability). R^2 is an absolute measure, it also includes variation explained by the Z and w variables. Therefore R^2 should not be used as a criteria for stability analysis.

Comments: A review of the allocative error approach and multiple regression approach provides insights to the researchers concerns about risks involved with new technology. The allocative error approach employed by Roe and Nygaard models risk indirectly using an expected utility framework. Their analysis helped identify certain cognitive variables, i.e., experience, to be important in farmer decision in choice of technology. These results suggest the importance of attitudes in decision making, although evidence provided by Binswanger, 1980 and Rochin 1979 to the contrary points to economic constraints as the most important determinants of technology adoption. This does not imply that farmers are void of an adoption (learning) curve, but stresses the need to investigate their socio-economic situations, which to a great extent determine the shape of the adoption curve. Roe and Nygaard argue for critical policy analysis while stressing the use of HYV's. From their analysis, the HYV's are less stable (more risky) at low input levels, while traditional varieties although are low yielding but show higher stability (less risk). An important contribution of their study is that it draws attention to the need for evaluating technology under farmer conditions. Technology which is stable and profitable at input levels within the reach of the farmer will suceed even under a risky environment.

The multiple regression approach employed for analyzing experimental data has its own relative merits. However, in evaluating potential varieties due attention should be given to expected input use of the control variables (i.e., fertilizer, pesticides, etc.) under farmer conditions, rather then recommended amounts. This requires a systematic analysis of the on-farm situation through a series of "on-farm verification trials" with decisions concerning input use left to the farmer. The results of these trials would reveal an accurate performance of each genotype. Screening varieties under different farm constraint scenarios, appears to be logical way to incorporate farmer expectations from a variety. However, such experimentation can be best carried out with an integrated approach, i.e., farming system.

CHAPTER IV

IDENTIFICATION OF IMPORTANT VARIABLES IN DRYLAND FARMING IN SYRIA AFFECTING CHOICE OF TECHNOLOGY

This chapter examines some important features of farming under high risk conditions. The objective here is to show how certain socio-economic constraints may limit the farmer decision to adopt new technology. The material presented here focuses on those constraints which determine the type of action a farmer is expected to take. A particular case of dryland barley-livestock farming systems is presented. A number of statistical techniques are employed to identify the association of certain variables.

Barley occupies an important position in Syria's dryland agriculture. It is the main source of feed and forms a close complementary link with the livestock sector in the dry areas. However over the past 10-15 years, barley yields have been declining. These declining yield trends have been attributed to soil erosion and poor rangeland managment.* Moreover, input use in these areas has also been low, primarily because of the poor performance of nitrogen fertilizer under these conditions. The emphasis in this section is not on constraints posed by agriculture inputs, but on certain institutional and cognitive factors such as

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*Personal communication with ICARDA researchers.

Note: The author has spent two summers working with the Farming Systems Group at ICARDA.

extension, tenure, etc. Moreover special consideration is given to the 'experience' variable which is hypothesized to be crucial in determining future yield expectations.

The results presented here suggest that introduction of new techniques may meet only partial success. Farmers with long experience in dryland farming are cautious towards adoption of new technology. This attitude develops as a result of constant threat posed by the uncertainty of rainfall. Data from the Syrian dryland wheat and barley producers suggests that they respond to technology which enhances their ability to bring yield stability.

There are primarily two means of achieving increased production. Either by shifting the existing production function through technology or by readjustments in the existing resources through better "solution sets." The later could be achieved by adopting strategies which lesson risk and create new opportunities to supplement income i.e., cooperative farming. From a farming systems perspective research should provide insights on the potential design of technology within the socio-economic domains of its clients. This requires a thorough understanding of the farmer decision making process. This understanding would enable researchers to understand farmer constraints from the farmer perspectives, rather than simply noting farmer input use.

Data Utilization and Methodology

The data used in this section was collected during survey of barley farmers, Somel, 1981-82 [24]. The sample comprised of 168 farmers in three rainfall zones.[1/] Many questions asked in the survey dealt with qualitative variables. This information was analyzed using a Chi-square technique to determine the degree of association among variables.[2/]

Presentation of the Data

For a general picture of the major farming activities and their zonal distribution see Table 2. This table shows that in zones 3 and 4 barley and livestock are the major elements of the dryland farming system. In Syria wheat is the main staple and it is planted if possible. However, as the water requirements for wheat are high it is not a major component of the farming systems in zones 3 and 4.

Land Distribution

Land tenure can affect the use of modern inputs (i.e., fertilizer, pesticides, etc.). Individuals who rent on an annual share crop basis (both from government and other farmers) are faced with uncertainty or in some cases risk of not being able to use the same land in the future. Therefore, they tend to invest only in those inputs which bring short term returns. Table 3 shows the association between tennurial arrangements and the agriculture enterprise undertaken. It is often observed that land rented from the state or other farmers is allocated to a single activity i.e., barley, wheat or livestock. In the case of owned land or

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[1/] Zones 2 = 350 mm - 500 mm annual rainfall
Zones 3 = 200 mm - 350 mm annual rainfall
Zones 4 = < 200 mm annual rainfall

[2/] Chi-square hypothesis

H_0: Two variables are not associated

H_A: Two variables are associated

TABLE 2. Distribution of Major Activities Across Zones in Syria

Rainfall Zone	Number of Farmers Reporting These Activities				
	Wheat	Barley	Cotton	Livestock	Others
2 (350-500) mm	15	19	3	3	6
3 (200-350) mm	12	26	2	7	3
4 (less than 200) mm	6	45	1	17	1

Calculated

$X^2 = 21.94$

$n = 16$

CC (coefficient of contingency) = .35

Critical

$X^2 = 13.63$ at DF = 8
$\alpha = .10$

Hypothesis

H_0 = Zone and activity are independent

H_A = Zone and activity are dependent

Conclusion: Reject H_0

TABLE 3. Distribution of Major Activity and Type of Land Tenure

Tenure	Major Activity			
	Barley	Wheat	Livestock	Others
Rented from Other Farmer + State	29	9	4	0
Owned by Farmer	56	24	8	13
Joint Ownership	7	0	0	3

Calculated

$X^2 = 15.04$

$CC = .30$

$n = 150$

Critical

$X^2 = 10.65$ at $DF = 6$
$\alpha = .10$

Hypothesis

H_0 = tennurial arrangement & activity are independent

H_A = tennurial arrangement & activity are dependent

Conclusion: Reject H_0

joint ownership two activities often had equal important. This would suggest a portfolio diversification strategy to hedge against weather and price uncertainty. Note that in case of land rented from the state for short periods it would not pay to incur heavy fixed costs and a reasonable strategy is to maximize short run gains.

Information and Extension

One of the crucial issues facing any research organization is the linkages it must develop with the extension system to enable a smooth flow of information (solutions and problem identification). The need for a viable extension system can be illustrated by the following example, which demonstrates the farmer point of view about adoption of a new variety. In the barley survey farmers were asked whether they would adopt a variety if it became available and what characteristics they desired the most (see Table 4). The responses given show that farmers attitudes towards adoption of a new variety are dependent not only on its performance under local conditions, but also on the efficient working of an extension machinery. The table shows that varieties claiming higher yields require demonstrated performance over those varieties which claim combined improvements in yield, drought resistance and straw content. This suggests that under prevailing Syrian conditions varietal strategies for zones 3 and 4 should not overemphasize grain yields but also pay due attention to the forage content to complement the livestock interface.

To summarize, there is evidence to suggest that instead of focusing on the conventional strategy of breeding for high yield and drought

TABLE 4. Distribution of Characteristics Most Desired by Farmers in a Variety and Adoption of a New Variety[1/]

Response	What Farmers Want Most in a Variety	
	High Yield	Combination Hy + Long Straw, Drought Resistance, Others
Yes	7	10
Have to see how others do with it	22	7
Need some demonstration	12	12
Does now know	2	1
No	2	2

[1/]Question: If a new variety was available would you use it?

Calculated

$X^2 = 11.79$

CC = .37

n = 74

Critical

$X^2 = 9.24$ at DF = 5
$\alpha = .10$

Hypothesis

H_0 = Adoption of variety and varietal traits are not associated

H_A = Adoption of variety and varietal traits are associated resistance and straw content improvement (particularly straw palatability/nutritional value) would be preferred, Figure 2.

The Experience Dilemma

It is often hypothesized that farmers are rational economic actors and allocate resources in an optimal manner. This Schultzian hypothesis cannot be criticized under normal conditions. Numerous other studies (for instance David Hoppers [24] work in India) have demonstrated the economic rationality of farmers. However, farmers under dryland conditions show a more conservative rationality. In other words decision making under uncertain and risky conditions leads the farmer to make conservative estimates in his expectations of the future. A plausible hypothesis is that expectations are based on past experiences. This hypothesis is tested by studying the association between years of farming experience and future yield expectations through correlation and linear regression.

Results of Correlation and Regression

(Data Source: "Barley Survey" 1981, 82, ICARDA, Syria).

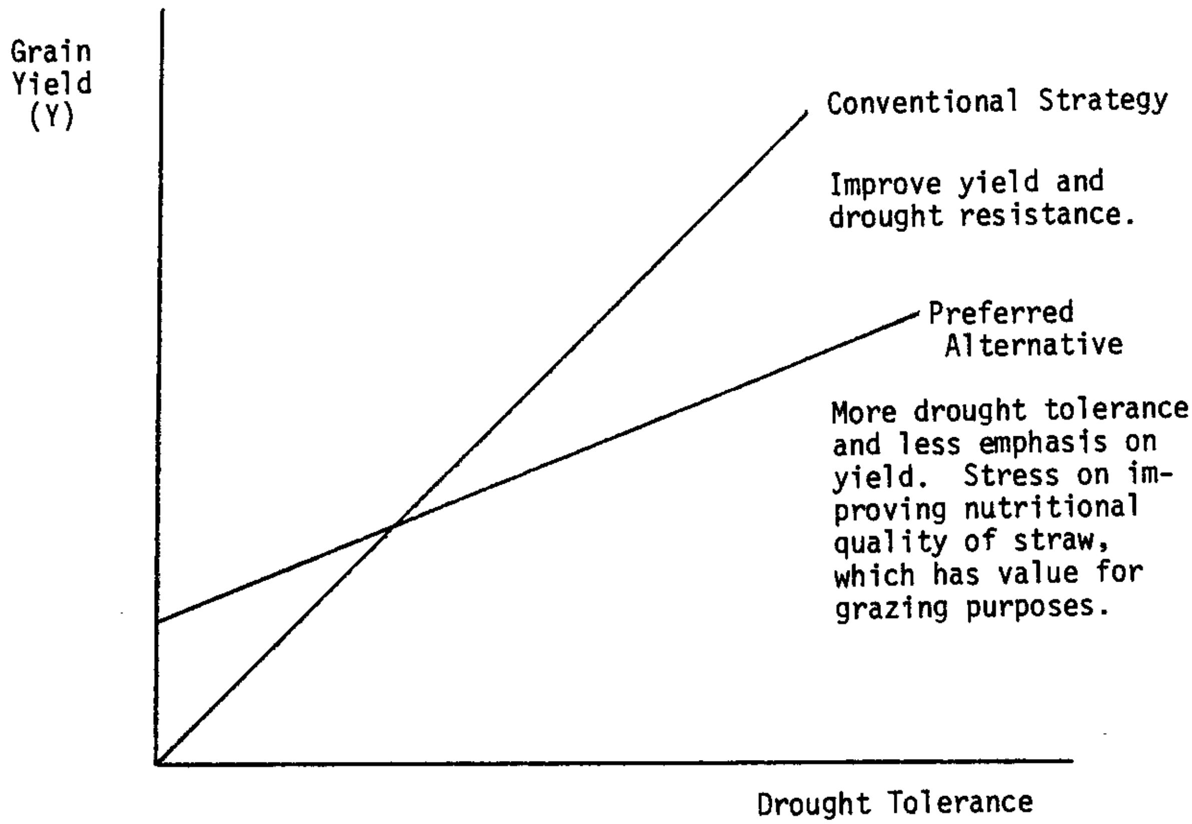
Correlation

1. Years of experience and normal year yield expectations

   r = -.19
   n = 154

2. Years of experience and good year yield expectations

   r = -.86
   n = 154



(Source: Illustration by the author)

Trade-Off Between Conventional
and Preferred Alternative Breeding
Strategies Under Dryland Conditions

FIGURE 2

Regression ($y = \alpha + \beta x$)

1. Good year = 16.11 - .45 experience

   R^2 = .74
   t = -.74

   Normal year = 6.94 - .46 experience

   R^2 = .32
   t = -.20
   n = 154

Note: Good year and normal year signify the farmers perception of a good, normal crop. No exact yield levels were signified.

First, look at the correlation coefficients especially at the negative sign. This sign suggests that as farmers gain more experience, their future yield expectations decline.

The regression results however partially weaken the above ascertion. Both coefficients in the two regressions are not significantly differemt from zero. This would imply that farmer's experience under dryland conditions plays no role in formulating future expectations. Can we then say that experience with dryland farming does not make any difference, rather external constraints as rainfall, temperature, topography, are the main determinants of yield. This dilemma is left unresolved for further research and evidence. Nevertheless, the importance of the experience variable for diffusion and adoption of new technology cannot be undermined.

Due to the extreme rainfall fluctuations under dryland conditions farmers have a preference for stability over marginal improvements in output upon analysis. The revealed subjective estimates for both yield expectations, and expectations regarding the probability distribution of future crop years (good, normal, poor) show divergence during short time intervals.[1/]

One inference which is drawn from the analysis presented in Appendix A is that dryland farmers cannot be sure of the marginal productivity of other inputs under their own conditions. This would imply a strong preference for demonstrated performance, before experimenting with new technology.

An analysis of the barley data also shows that farmers assign minor importance to certain inputs, i.e., herbicides, pesticides, seed treatment. It has been demonstrated for other crops i.e., wheat, rice, etc. that effective pest management can lead to 10-15% increased yields. When Syrian barley producers were asked whether weed or pest attack was a problem on their farms, a majority responded that it was not. When a farming systems team of plant protection experts visited the fields they sometimes found incidence of pest attack well above the threshold level defined on basis of plant disease incidence level (see Table 5). From the analysis of 75 respondents it was found that only 15% of them used any seed treatment. A focus on some of these components of a 'Package of technology' would help enhance yield stability. However the costs of these components relative to their returns is not presently available.

[1/] For a statistical illustration see Appendix A.

TABLE 5. Incidence of Disease in Barley Crop

Disease and Other Damage	West 2	West 3	West 4	NE Zone 2	NE Zone 3	NE Zone 4
Number of Farms	27	22	27	19	27	36
Covered Smut.						
Mean severity (0-9)	.2	.1	0	.2	.2	.2
Lose Smut.						
Mean severity (0-9)	.4	0	0	.1	0	0
Scald						
Mean severity (0-9)	2.0	1.7	2.1	1.9	1	.7
Powdery Mildew						
Mean severity (0-9)	1.0	0.2	.8	0	.1	0
Stripe						
Mean severity (0-9)	.8	.7	.1	0	0	0
Yellow rust						
Mean severity (0-9)	0	0	3.7	0	0	0
Brown rust						
Mean severity (0-9)	.4	.2	.1	0	0	0
Net Blotch						
Mean severity (0-9)	.7	.6	.5	2.7	1.5	1.7
Spot Blotch						
Mean severity (0-9)	.2	.5	.9	0	.4	.7
BY DV						
Mean severity	.2	.5	.9	0	.4	.7
Bacterial diseases (0-9)	.1	.2	.3	0	.1	0
Yellowing (0-9)	.3	.9	.9	0	.2	.4
Frost damage	1.0	1.6	1.9	2.1	1.1	1.7

Source: Farming Systems Program, Barley Survey Data, 1982.

Note: A scale of 0-9 shows level of intensity.

CHAPTER V

SUMMARY AND CONCLUSIONS

The objectives of this paper were to review literature on risk and uncertainty research related to varietal evaluation and to identify important variables which influence the farmer decision making process in choice of technology, with special emphasis on varieties.

Two approaches to the evaluation of risk and uncertainty variables in varietal evaluation were identified. The allocative error approach employed by Roe and Nygaard is discussed in chapter III. This approach illustrates the importance of risk in the choice amongst traditional vs. high yielding varieties (HYV's). The authors concluded that at low input levels HYV's are riskier to produce than traditional varieties. They show that years of experience with a particular variety determines efficient resource allocation amongst HYV's and traditional varieties. The major policy implication of their study is that governments should not discriminate against the use of traditional varieties, because under high risk conditions they provide yield stability.

The multiple regression approach reviewed in this paper was ICRISAT's methodology for evaluating potential varieties. This approach screens varieties on the basis of stability and adaptability. An analysis of single year of wheat and barley trial data indicated that while ranking varieties in Plant Breeding research, other socio-economic variables as cash constraints, markets, prices etc. should be considered (26). However, this present approach does not specifically take into account these variables.

Both varietal evaluation approaches incorporate risk as a variable affecting varietal choice. The allocative approach accounts for risk in an expected utility framework, while the multiple regression approach used by the research centers uses stability (standard deviation and variance) of varietal yields as a proxy for measuring risk.

Field experiments indicate that farmers are not only concerned with improvements in yields and stability. Other characteristics relevant in Syria include baking quality, color, straw and value of the aftermath which are considered while choosing among varieties.

It is often argued that field-varification trials adequately serve the purpose of incorporating all relevant information considered important by the farmers in choice of varieties. Nevertheless, the results obtained by varification trials usually only demonstrate the performance of HYV's under recommended input levels and farmer management; they do not provide estimates of expected results when farmers make the resource allocation decisions. Of course poorly administered field work may also lead to erroneous results and biased data.

A more appropriate evaluation procedure appears to be on-farm trials conducted under farmers own conditions. This allows the plant and social scientist to realistically evaluate the performance of potential varieties.

This paper explains variables affecting decision making strategies adopted by farmers under conditions of risk. It is hypothesized that by studying these strategies we can improve our understanding of the variables affecting choice of technology. On the basis of this hypothesis a research proposal is outlined in appendix B. This proposal is based recent experience in Syria.

In chapter IV certain cognitive and socio-economic characteristics, i.e. experience, tenure etc. were identified affecting farmer decision strategies. The evidence presented there highlights the urgent need to evaluate sequentially the stages when a farmer considers modifying his routine resource allocation strategy. From my experience with rice farmers in Gujaranwala (Pakistan), it appeared that small rice farmers consistantly change their input decisions in a step wise fashion as more information becomes available. A small farmer after planting the rice nursery assesses further requirements of water. If there is heavy rainfall he will change his strategy for weeding or pesticide use. This implies that a routine strategy is consistantly being revised as knowledge of the farmer changes.

The current emphasis in risk and decision theory is more on formulation of expectation models, derivation of farmer utility functions under different expected utility (hypothesis) assumptions. However, there is an urgent need to operationalize the theory at the local level. To make it more applied and dynamic so as to meet the applied researchers needs. As most less developed countries are constrained by the availability of highly trained professionals a pragmatic approach to understanding decision making is required which will be more useful to extension workers and research station staff.

APPENDIX A

A STATISTICAL COMPARISON OF FARMER RESPONSES TO QUESTIONS CONCERNING PAST AND FUTURE YIELD EXPECTATIONS[1/]

This short note illustrates a comparison of farmer interview responses related to future weather and yield expectations. An initial screening of the data on two different responses to expectations showed marked variation. Farmers were asked the following questions during two different visits, with a 4-5 month interval.

Questions

1. Out of the past 10 years how many were good, bad or normal?
2. What are the yield expectations in good, bad or normal years?

Note: A good, bad or normal year was not defined in the questionnaire.

A number of statistical tests were conducted. These tests indicate that there is no statistical difference in the two responses to good and normal year yield and weather expectations. However, farmers responded differently to expectation questions regarding poor years in the two visits. This is illutrated in the analysis that follows.

Description of the Sample

The data used here were collected by the farming system program at ICARDA during 1981-82. The sample chosen comprised of 168 farmers.

[1/] The information used in this analysis was provided by the farming systems group at ICARDA, Syria.

These farmers represent more then 95 percent of the Syrian dryland production area, spread across three different rainfall zones. The dryland area of Syria was divided into two regions namely western and north eastern region and within each region a proportional sample was drawn on basis of the area under barley production. Farmers in each village within a Mohafazat (see Table 2 for sampling distribution) were selected on random basis.

In this analysis only 77 farmers were included who had responded to the two questions in both visits. Out of the remaining 91 farmers, 32 responded they did not know the answers to the questions (in other words were reluctant in revealing their expectations). One of the farmers answered the question in the first visit but did not respond in the second visit. The remaining farmers were not present during one of the two visits.

The results which follow only include 77 farmers who responded in both visits. It is also important to point out the years of farming experience the farmers in the sample had, only 3 farmers had less then 10 years of farming experience, while the average farming experience was 28 years.

Hypotheses Testing and Results

Three types of tests were conducted to gain insight into the reliability of farmer subjective estimates under conditions of risk and uncertainty.

The tests are as follows.

1. A pairwise comparison to see the differences in responses during good, bad and normal years.

TABLE 2. Sample Distribution

	Zone 2		Zone 3		Zone 4		Total	
	No.	%	No.	%	No.	%	No.	%
Hasakeh	15	29.4	15	29.4	18	35.3	48	31.4
Ragga	6	11.8	12	23.5	12	23.5	30	19.6
Dier ez-Zor	-	-	-	-	6	11.8	6	3.9
Sub Total	21	41.2	27	52.9	36	70.6	84	54.9
Aleppo	18	35.3	9	17.6	9	17.6	36	23.5
Hama	6	11.8	9	17.6	3	5.9	18	11.8
Homs	3	5.9	3	5.9	3	5.9	9	5.9
Idleb	3	5.9	3	5.9	-	-	6	3.9
Sub Total	30	58.9	24	47.0	15	29.4	69	45.1
Total	51		51		51		153 *	

* Note: The sample size for Aleppo Hama, Homs and Idleb was increased by 15. The researchers considered these areas to have special potential for improvement. However, in the empirical work these areas are properly weighed.

Source: Farming Systems Program, ICARDA, Syria.

2. A Wilcoxon rank test to determine the difference in overall estimates.

3. Expected long run yields under the two response scenarios.

Results are shown in Table 1. The hypotheses is:

$H_0 = U_1 = U_2$ (no difference in responses)

$H_A = U_1 \neq U_2$ (difference in responses).

The decision rule is accept H_0 if:

t calculated is greater then t tabulated

where $\overline{d}$ = average of the difference between responses

Results in Table 3 show that there is no statistical difference between the responses given in the first and second interview. Although a look at the preliminary observations showed numerous cases which exhibit wide divergence between the two estimates revealed in the first and second interview. It is important to note the difference in the mean responses $\overline{R}_1 = 3.37$ and $\overline{R}_2 = 2.47$ and the corresponding coefficient of variation (CV) statistic in the table for the poor year. It appears that farmers are uncertain about yields in a poor year. However, it must be pointed out that 1982 was a poor year (year for collecting data), hence farmers might be underestimating expected yields in the future for the second response. This could have lead to certain inconsistencies in estimating future yields.

<u>Non-Parametric Wilcoxon Test</u>

This test was conducted for only n=75 in order to facilitate data handling on a programmable calculator (HP-41C). The Wilcoxon test

TABLE 3. Results of Paired Comparison Test for of Good, Bad, Normal Year

Year	Calculations	t	H_0: $U_1-U_2 = 0$	$H_A: U_1 \neq U_2$	Basic Statistic	CV
Good Year	$\bar{D}$ = .10 SD = 1.18 N = 77	t(cal)=.75 AT alpha=.10 t(tab)=1.671	Do not reject	-	$\bar{R}_1$ = 2.49 $\bar{R}_2$ = 2.35 SD (R_1) = 1.0 SD (R_2) = .94	R_1 = 40% R_2 = 40%
Poor year	$\bar{D}$ = -.20 SD = 2.29 N = 77	t(cal)=.77	Do not reject	-	$\bar{R}_1$ = 2.57 $\bar{R}_2$ = 2.77 S_D (R_1) = 1.47 S_D (R_2) = 1.72	R_1 = 57% R_2 = 62%
Normal year	$\bar{D}$ = .18 SD = 2.19 N = 77	t(cal)=.72	Do not reject	-	$\bar{R}_1$ = 5.0 $\bar{R}_2$ = 4.81 S_D (R_1) = 1.59 S_D (R_2) = 1.65	CV = 32% CV = 34%

Note: (a) R_1 and R_2 are interview responses in the first and second visit

$t = \bar{d} / SD/\sqrt{n}$ n=77

(b) Data analyzed in HP-41C programmable calculator.

Source: Farming Systems Program, ICARDA, Syria.

compares the paired response of the weighted expected yields over a 10 year period for each farmer.

$$\text{Expected (yield)} = \frac{1}{10} \sum_{i=1}^{3} K_i J_i$$

K_i = good year

bad year   Index: i=1,2,3

normal year

J_i = expected yield in good year

expected yield in bad year

expected yield in normal year

The Wilcoxon test led to the rejection of the null hypothesis that weighted expected yields in both responses are equivalent (Table 4). It must be noted that this is the result of only one statistical test and cannot be regarded conclusive.

Estimation of Long Run Expected Yields (LREY)

A comparison of LREY was made by estimating the long run yield expectation E(Y). Where E(Y) is calculated as:

$$E(Y) = \frac{1}{n} \cdot \frac{1}{10} \sum_{i=1}^{3} K_i J_i$$

Index

i = 1, 2, 3,

K_i = good year

bad year

normal year

J_i = expected yield in good year

expected yield in bad year

expected yield in normal year

TABLE 4. Wilcoxon Rank Test

Note: The Wilcoxon statistic was calculated as follows:

$V = 231$

$$Z = \frac{V - \frac{n(n+1)}{4}}{\sqrt{\frac{n(n+1)(2n+1)}{24}}} = -6.3$$

Here V is the sum of ranks of positive differences.

$H_0 = U_1 - U_2 = U_2$

$H_A = U_1 \neq U_2$

Result: Reject the null hypothesis at Alpha = .05

The following results were obtained:

(1) First response 902 kg/ha n=35

(2) Second respone 799 kg/ha

Note: difference between 1 and 2 is 11.4%

These estimates are comparable to those obtained by Somel (1982). The results reported by him for 168 farmers are shown in Table 5. This comparison suggests that there are no significant difference in long run expectations from the information provided in the first or second visit.

Summary

The results presented here show that there is a significant statistical differences in responses given by farmers in two different visits. Their expectations concerning future yield expectations are the same whether estimated from the data obtained during the first or second visit. However, there is as expected great deal of uncertainty regarding yields in poor years (when rainfall is low). It is important to note that the Wilcoxon test rejected the hypothesis that first and second response are the same. This has important implications in estimating subjective production functions with expected yield as the dependent variable (illustrated by Roe and Nygaard in Chapter III of the text). As mentioned earlier a glance at the data shows considerable variation in the two responses obtained during short intervals. This questions the reliability of the information. A fruitful exercise would be to estimate subjective production functions using the two estimates and then check the difference. However, at present such information is not available for this type of analysis. It may also be pointed out the

TABLE 5. Expected Long Run Barley Yields: Projections from the First Visit Responses

Region in Syria	Zone	Expected Long Run Yields (kg/ha)
North East	2	997
North East	3	778
North East	4	557
Western	2	867
Western	3	967
Western	4	573

Source: Somel, Results from the Barley Survey, a set of reports and memos, 1982.

interviewer bias in studies dealing with farmer expectations needs to be watched very carefully.

APPENDIX B

IDENTIFICATION OF VARIABLES AND TIMING OF FARMER DECISION STRATEGIES UNDER SYRIAN DRYLAND CONDITIONS--A RESEARCH PROPOSAL

This appendix builds on the literature review presented in chapter two of the text.

Background

Understanding the factors influencing farmer decision making regarding crop varieties is important in the design of technology. It was shown in the text not only are certain variables important in the decision process, but often it is a set of constraints which determine the action taken by a farmer. This study will investigate various decision strategies followed by dryland farmers. The major focus is on barley-livestock farming systems, and the decision strategies related to production are of special interest. The major crop grown under dryland conditions in Syria is barley.

ICARDA has a mandate to improve the yields of barley in dryland areas. Barley (Hordeum valgare) has historically been grown as a cereal crop in Asia and Africa. Although its importance as a source of nutrition is on the decline. Nevertheless, it is the main forage crop for livestock in the drier regions. Its natural ability to grow under these conditions makes it highly suitable for dryland agriculture.

The present status of barley is well appraised in the opening address of the fourth Regional Winter Cereal workshop on barley 1977 [26].

> "...It appears that until recently barley has been treated as an inferior crop especially when compared with wheat. This has been mainly due to the minimal encouragement in terms of price support given by governments and the almost total lack of improved varieties and practices available to the producers. This situation has also been worsened by recent strides that have taken place in wheat varieties and production improvements."

These comments suggest that barley has remained a much neglected crop in the eyes of researchers. Although its economic importance justifies special attention. There have been drastic increases in the yield and production of wheat, whereas barley yields have remained relatively static as stated earlier in Chapter IV. As a result wheat production became increasingly favored by farmers, this lead to a continuing decline in the area and production of barley. A summary of barley production and practices in Syria is shown in Table 1.

In order to gain information about the production practices followed in barley production in Syria an extensive farming systems survey was carried out during 1981 and 1982. A wealth of information has been generated which will provide background for this study. This data will also enable to test some preliminary hypothesis stated later. In dryland agriculture it is important that a 2-3 year data set is used to account for rainfall variability.

Preliminary results from the ICARDA survey open up new avenues for research. The purpose here is not to give a detailed account. However, it is now well established that the production area in Syria can be divided into two main regions (see map).

(a) North Western Region: Aleppo, Hama, Homs, Idleb

(b) North East: Dier-ez-Zor, Hasakeh, Idleb

TABLE 1. Barley and Wheat Production in Syria (1979)

Area	
Total cultivated land	5,686,000 hectares
Total area sown to barley	1,102,000 hectares
Total area sown to wheat	1,445,000 hectares
Production	
Total barley	395,000 metric tons
Total wheat	1,320,000 metric tons
Yield[1/]	
Barley	590 kg/ha
Wheat	917 kg/ha
Uses of Barley	
Animal Feed	100%

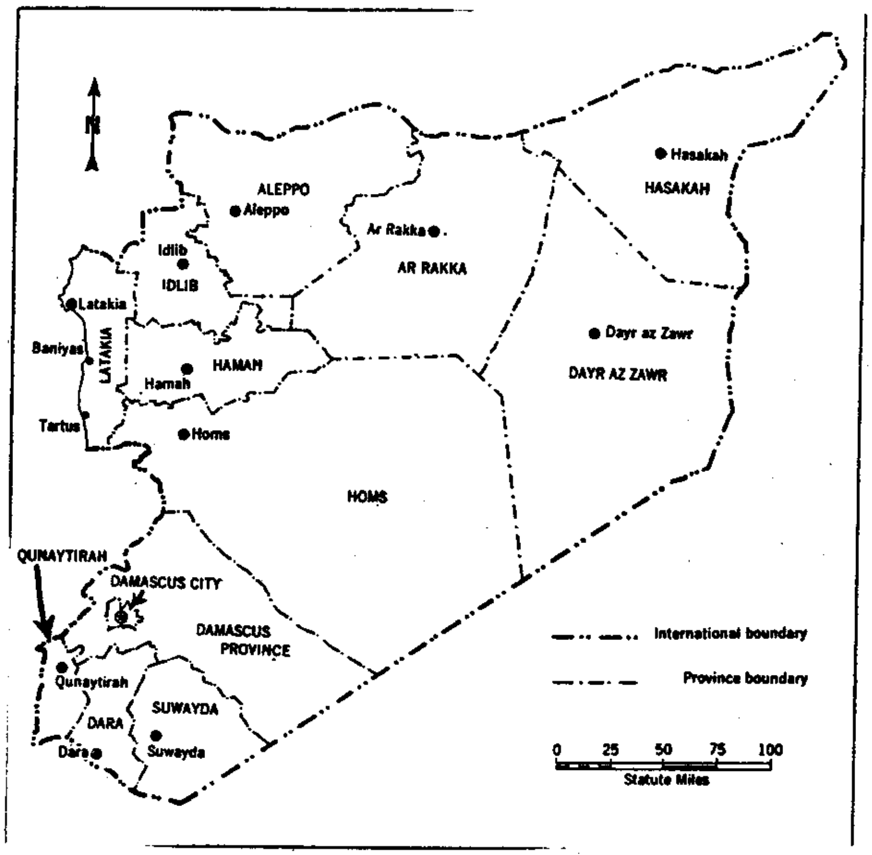
Barley is grown mostly in the low rainfall areas. Seventy percent of the acreage is sown in areas of less then 300 mm. rainfall, and 20% in the 300 to 400 rainfall zones. Other features of barley:

Normal sowing date: October to November
Normal harvest date: May to June
Main varieties: Arabic Abiad local 60%, Arabic white 20%
Main diseases: powdery mildew, leaf rust
Main insect problems: stink bug, aphids

In dry years barley acreage is sold for grazing.

Source: ICARDA (1977), Syrian Statistical Abstracts, 1979.

[1/] Average wheat yields for last 5 years = 980 kg/ha.
Average barley yields for last 5 years = 560 kg/ha.



Source: U.S. Army Area Handbook for Syria

Map of Provinces and Principle Cities of Syria

FIGURE 1

These two regions have significant differences based on tennurial arrangement, land and input use etc. Each of these regions is divided according to three different rainfall zones. ICARDA's survey shows that yields in environments experiencing above average conditions are more stable then areas with poor conditions. This would suggest that a risk averse farmer will give more weight to the uncertainty associated with adverse conditions. Hence make him more reluctant to adopt changes which may work under average conditions.

Objectives:

The objectives of this study are as follows.

1. To model important variables influencing choice of varieties in production decisions.
2. To measure the extent of barley and livestock interactions in formulation of production strategies.
3. To determine resource allocation efficiency under conditions of risk and uncertainty.

Hypotheses

These three objectives will be guided by the following hypotheses.

1. Barley producers in the dryland areas are risk averse and allocate resources optimally.
2. They adopt strategies which emphasize stability over higher yields.
3. Resource allocative errors committed once limit future experimentation with technology. (Note: It is recognized that all farmers do not fall under this category.)

Model and Identification of Variables

Appropriate statistical hypothesis will be formulated to achieve the objectives. A decision model will be constructed to gain insight into the various strategies employed by farmers. Specifically, a strategy here implies a certain course of action taken by a farmer within a given constraint set. An attempt will be made to understand the outcomes of these strategies. Maximizing techniques will be employed after determining the feasibility of a particular action.

The allocative efficiency will be determined through a production function analysis. In this regard the Cobb-Douglas production function of the form

$$Y = AX_1^{\beta_1}X_2^{\beta_2}$$

will be used. The allocative efficiency will be studied with appropriate econometric analysis.

One problem which may be pointed out at this stage is the difficulty of assuming that all farmers are profit maximizers. Many farmers grow barley for subsistance purposes and do not engage in market activities. However, this problem can be overcome by assuming that all farmers are utility maximizers. This also becomes a testable hypothesis, and optimizing rules for the production function analysis will depend on the validity of the assumptions of utility maximization. The element of risk will be included using an expected utility framework.

A list of variables affecting barley production is summarized in Table 2. A major characteristic of barley production under dryland conditions is low input use. In many instances barley is not harvested but grazed to animals. This is especially true in poor years, when the opportunity cost of harvesting exceeds the expected returns.

TABLE 2. Barley Survey:
Summary of Variables for the Western Region
(Aleppo-Homs-Hama-Idleb)

Variables and Other Information	Zone 2	Zone 3	Zone 4
1. Sample size	30	24	30 (15) should be weighted 0.5
2. Average yield (kg/ha) 1980/81. (Includes areas which have been grazed. These areas have been coded as having zero yield.)	878	676	426
3. CV of average yield	83.5%	77.5%	69 %
4. Barley area 1980/81 (ha)	12.9	23.4	12.1
CV	251 %	184 %	82.5%
5. Barley area 1981/82 (ha)	13.0	24.4	13.2
CV	257 %	176 %	76.2%
6. For barley production 1980/81 was a:			
a. Good year	23.3%	4 %	6.7%
b. Poor year	33.3%	50 %	36.7%
c. Average year	43.3%	46 %	56.7%
7. a) Farmers who were able to harvest barley in 1980/81.	96.7%	87.5%	n: 29-93%
b) Farmers who had all or part of barley grazed in 1980/81 instead of harvesting.	26.7%	62.5%	n: 29-79%
8. Reasons for grazing barley instead of harvesting:			
n	8	15	23
(1) Poor yield	75 %	73 %	83 %
(2) Other	25 %	27 %	17 %

TABLE 2 (Continued)

Variables and Other Information	Zone 2	Zone 3	Zone 4
9. a) Rainfed barley grazed at the green stage	13.3%	8.3%	13.3%
b) Irrigated barley (n)	7	6	3
c) Irrigated barley grazed at the green stage	86 %	67 %	33 %
10. Circumstances for grazing barley at the green stage			
(0) Does not graze at the green stage	66.7%	79 %	83.3%
(1) In good or exceptionally good years	13.3%	16.7%	13.3%
(2) Rarely or sometimes	13.3%	-	3.3%
(3) Other	6.7	4.2	-
11. Expected yields (sh/ha)			
a. In good years - (c.v.)	15.2 (48%)	19.0 (32%)	12.6 (46%)
b. In poor years - (c.v.)	1.8(132%)	1.2(211%)	0.5(201%)
c. In average years - (c.v.)	7.6 (56%)	8.8 (39%)	5.0(46%)
(This contains zero values for grazing in poor years. The weight of shwals are variable and these figures have to be converted to kg/ha).			
12. In 10 years the average number of expected:			
a. Good years	2.4	2.4	2.3
b. Poor years	2.4	2.8	3.2
c. Average years	5.2	4.8	4.6
d. No answer (n)	10	10	10
(Question was asked as the pattern experienced in the last 10 years.)			

TABLE 2 (Continued)

Variables and Other Information	Zone 2 (Rank)			Zone 3 (Rank)			Zone 4 (Rank)		
13. Constraints to improved yields ranked 1, 2 or 3: Number of times.	1	2	3*	1	2	3	1	2	3
(1) Rainfall	30	-	-	24	-	-	30	-	-
(2) Soil	-	11	15	-	6	12	-	9	15
(3) Management	-	16	9	-	16	3	-	20	8
(4) Lack of Inputs	-	-	2	-	-	1	-	-	-
(5) Price of Inputs	-	-	1	-	-	-	-	-	-
(6) Weeds	-	-	1	-	-	-	-	-	1
(7) Price of barley	-	-	1	-	-	-	-	-	-
(8) Variety	-	-	1	-	1	1	-	-	1
(9) Credit	-	-	1	-	-	-	-	-	-
(10) Other	-	3	1	-	-	1	-	1	1

*There is a programming erros in this column. It will be rectified later.

Variables and Other Information	Zone 2	Zone 3	Zone 4
14. Most important activity:			
(1) Wheat	26.7%	8.3%	3.3%
(2) Barley	36.7%	50 %	36.7%
(3) Lentils			
(4) Chickpeas			
(5) Water melon			
(6) Cotton	3.3%		
(7) Olives			
(8) Sheep	13 %	25 %	43.3%
(9) Other	23.3%	16.7%	12.3%

Source: Data provided by Somel, Kotlu (ICARDA).

TABLE.2. Barley Survey:
Summary of Variables for the Eastern Region
(Hassakeh-Deir-ez-Zor-Raqqa)

Variables and Other Information	Zone 2	Zone 3	Zone 4
1. Sample size	21	27	36
2. Yield average (kg/ha) 1980/81. (Includes areas which have been grazed. These areas have been coded has having zero yield).	1276	924	812
3. CV of average yield	42 %	32 %	44 %
4. Barley area 1980/81 (ha)	24.0	42.9	28.3
CV	133 %	158 %	198 %
5. Barley area 1981/82	22.6	39.3	24.7
CV	121 %	162 %	169 %
6. For barley production 1980/81 was a:			
a. Good year	62 %	33 %	4.7%
b. Poor year	0 %	0 %	4.6%
c. Average year	38 %	67 %	52.8%
7. a) Farmers who were able to harvest barley in 1980/81.	100 %	100 %	100 %
b) Farmers who had all or part their barley grazed in 1980/81 instead of harvesting	9.5%	7.4%	25 %
8. Reasons for grazing instead of harvesting:			
n	2	2	9
(1) Poor yield	50 %	50 %	67 %
(2) Other	50 %	50 %	33.3%

TABLE 2 (Continued)

Variables and Other Information	Zone 2	Zone 3	Zone 4
9. a) Rainfed barley grazed at the green stage	76.2%	77.8%	50 %
b) Irrigated barley (n)	1	1	3
c) Irrigated barley grazed at the green stage	0 %	0 %	0 %
10. Circumstances for grazing barley at the green stage			
(0) Does not graze at the green stage	23.8%	22.2%	50 %
(1) Sometimes or rarely	4.8%	0 %	0 %
(2) In good or exceptionally good years	23.8%	22.2%	22.2%
(3) Every year	47.6%	55.6%	27.8%
(4) Other	0 %	0 %	0 %
11. Expected yields (sh/ha)			
a. In good years - (c.v.)	16.9 (30%)	15.4 (32%)	13.8 (40%)
b. In poor years - (c.v.)	1.8 (90%)	0.04(520%)	0.5(337%)
c. In average years - (c.v.)	8.7 (33%)	6.3 (29%)	5.6 (31%)
(This contains zero values for grazing in poor years. The weight of shwals are variable and these figures have to be converted to kg/ha.)			
12. In 10 years the number of expected:			
a. Good years	2.4	2.8	2.1
b. Poor years	2.2	2.2	3.5
c. Average years	5.4	5.0	4.4
d. No answer (n)	6	6	10
(Question was asked sas the pattern experienced in the last 10 years.)			

TABLE 2 (Continued)

Variables and Other Information	Zone 2			Zone 3			Zone 4		
	(Rank)			(Rank)			(Rank)		
13. Constraints to improve yields, ranked 1, 2 or 3: Number of times.	1	2	3	1	2	3	1	2	3
(1) Rainfall	21	-	-	27	-	-	36	-	-
(2) Soil	-	3	9	-	12	11	-	15	13
(3) Management	-	18	3	-	14	9	-	19	9
(4) Lack of Inputs	-	-	-	-	-	-	-	-	-
(5) Price of Inputs	-	-	-	-	-	-	-	-	-
(6) Weeds	-	-	-	-	-	-	-	-	-
(7) Price of barley	-	-	-	-	-	-	-	-	-
(8) Variety	-	-	1	-	-	-	-	-	-
(9) Credit	-	-	-	-	-	-	-	-	-
(10) Other	-	-	1	-	-	-	-	-	4
14. Most important activity:									
(1) Wheat		23.8%			22.2%			2.8%	
(2) Barley		28.6%			40.7%			25.0%	
(3) Lentils									
(4) Chickpeas									
(5) Water melon									
(6) Cotton		19.0%			3.7%			2.8%	
(7) Olives		4.8%							
(8) Sheep		23.8%			33.3%			66.7%	
(9) Other								2.8%	

Data Collection and Survey Method

Sources of Data

Both primary and secondary sources will be used in this study. Two year data is already available with the farming systems group at ICARDA. However, this data will only be partially useful for this study. A comprehensive questionnaire will be prepared and information collected through a series of visits.

A sample design and frame is already available for this proposed research. The same sample farmers will be chosen which form the past sample of ICARDA survey.

There are two main barley producing regions namely:

1. North Eastern Region: Dier-ez-Zor, Hasakeh Raqqa
2. North Western Region: Aleppo, Hana Homs, Idleb

These seven Mohafazats were selected on the basis of the average of 1979-80 area wise distribution figures. They represent the following area as total of Syria's barley producing area.

1. 94.3 percent of barley in Zone 2
2. 94.3 percent of barley in Zone 3
3. 97.9 percent of barley in Zone 4

Relatively speaking these seven Mohafazats represent 95 percent of the total barley produced in Syria.

As, the area is almost similar in magnitude in the three zones. A sample has been selected on basis of proportion. A sample size of at least 25 farmers is desired for each zone. Depending on the finances it will be decided whether either eastern, western or both of these regions will be included in the study. This decision could double the sample from 75 to 150 farmers.

Interviewer Selection and Training

This research will be conducted with the collaboration of the farming systems group at ICARDA. The group there already has a well trained staff for interviewing. Transportation and lodging support will be provided by the research center.

The methodology and design of this study will be discussed with the ICARDA staff. This will help in improving the survey of the study.

Funding for this project will be secured through an International sponsor.

A Pilot Study in Quetta, Pakistan

A pilot study is also proposed for Quetta in Pakistan. The climate conditions are very similar to those in the dryland areas of Syria. The interest in Quetta is limited to studying the decision making strategies of barley producers. This will enable a comparison of the Syrian data with Pakistan. The Arid Zone Research Institute (AZRI) has shown interest in this research. The possibility of this pilot study will be further explored with the sponsor.

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