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Farmer participatory screening of maize seed varieties for suitability in risk prone, resource-constrained smallholder farming systems of Zimbabwe

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The top down approach to hybrid seed production and variety selection in Sub-Saharan African countries has resulted in farmers being reduced to simple adopters of seed varieties mostly not suited to their pedo-climatic conditions and socio-economic circumstances. This has led to rates of take-up of these seed varieties being painstakingly slow, a situation that threatens to thwart efforts directed at the attainment of food security in the region. In this study, farmer participatory research techniques were used to screen maize seed varieties for their suitability in the semi-arid risk prone areas of Zimbabwe. Farmers were found to prefer drought resistant short season varieties and to retain seed from previous harvests for future planting seasons reflecting their tendency towards risk aversion. The study thus buttresses the need to include farmers in research geared at generating and selecting maize seed varieties that are suitable to their local environments.

Key words: Farmer participatory research, stochastic dominance, screening, Sub-Saharan Africa, seed.

INTRODUCTION

The use of quality seeds, along with other inputs and appropriate cultural practices, is recognized as the most cost-effective way of increasing crop production and productivity. The continuous and unhindered economic access by farmers, especially smallholders, to good seeds, is therefore of paramount concern. In other words, seed security, both in its wider sense and its more restrictive or emergency connotation, should be accorded high priority in national, regional and global agriculture. A seed security programme can be defined as a series of activities developed to ensure access by farming households to adequate quantities of quality seeds and plant materials of adapted crop varieties at all times (FAO, 2001). According to Wobil (1998) seed security is a *sine qua non* for food security.

In Sub-Saharan Africa, maize is by far the most important food crop especially for the resource-constrained rural poor. One of the biggest problems that threaten to thwart efforts to improve maize productivity in smallholder

farming systems in the region is the shortage of the right seed varieties that not only suit the agro ecological conditions of the farmers, but are also in line with farmers' socio-cultural set up, including beliefs, attitudes towards risk and tradition (Blackie, 1994). Literature surveys of smallholder farmer seed practices in Sub-Saharan Africa have indicated that much of the information on the selection of suitable maize varieties by farmers was anecdotal and that farmer seed management was generally a neglected area (Rusike and Eicher, 1997, Wright et al., 1994; Tripp, 1995).

The positioning of small-scale rural farmers at the lower ranks of the income spectrum makes their decision-making on maize variety selection and evaluation prone to risk aversion. Resource poor farmers tend to consider the stability of the returns they get from technologies more than do well-off farmers (Hardarker et al., 1997). It then follows that for a particular maize seed variety to be attractive to farmers; it should both yield higher returns to farmer investment as well as have a stable return across a wide range of agronomic environments and pedo-climatic conditions.

In this study, Farmer Participatory Research (FPR) techniques were used to select the maize varieties that

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are most suitable to farmers in Zvishavane district of Zimbabwe in terms of the pedo-climatic conditions of the district and the farmers' risk attitude. The study combines farmers' own assessment and evaluation of the varieties using local criteria established by the farmers and stochastic dominance analysis to rank the maize seed varieties basing on risk efficiency.

Literature review and conceptual framework

Literature review

In southern Africa, the high rate of population growth, averaging about 3% per annum, requiring ever-increasing quantities of basic staple foods, stands in sharp contrast with the rapidly declining food production in the majority of the countries (Wobil, 1998). Cyclical droughts, floods and hurricanes in some of the countries and civil strife and wars in others exacerbate this decline. As a result, food shortages are emerging as a permanent feature in many countries and food aid and emergency seed supplies from external sources are becoming entrenched as a recurring phenomenon. This situation, according to Sperling et al. (2004), is unfairly at odds with the recognized potential of the region not only to feed itself, but also to have excesses for export.

In considering interventions that are likely to reverse the trend of recurring food shortages, seed security has been recognized as having the potential to serve as a major and the most cost-effective pathway to achieving significant advances in food productivity and production (Tripp et al., 1997). But only recently has this recognition begun to translate into practical action programmes to entrench seed security as a permanent feature of SADC agriculture.

Southern Africa region's seed systems are characterized by high reliance on the informal seed sector. This sector is made up of unregulated and uncontrolled seed operations and is largely represented by on-farm seed selection and multiplication efforts by the farmers themselves, seed exchanges among farmers and use of planting material saved from previous crop harvest. It is also characterized by absence of interventions by external organizations that are divorced from research and seed quality control and are confined to seeds which the formal sector largely does not consider profitable to embark on. For decades, the informal seed sector was neglected by national seed programmes in spite of its record of providing nearly 90% of total seed requirements in Southern Africa (Tripp, 1995). Along with the recent recognition of the potential of this sector in enhancing seed delivery has become a myriad of efforts, national, international and of NGOs to strengthen the sector. But it is important to avoid embarking on interventions in the sector which have the likelihood of so altering it that it ceases to present the advantages which presently make it attractive and preferred by the majority of small-scale farmers. Seed security activities, when carried out at

household and community levels in a participatory manner, may protect farmers from unpredictable small-scale calamities (Sperling et al., 2004).

Tripp et al. (1997) noted that the long-term solution to seed insufficiency, and hence food insecurity, among limited resource farming households lies much less in interventions in the formal sector which does not achieve immediate profitability from producing seeds of traditional food crops. He argues that the interventions should rather be through the strengthening of the informal seed supply sector and in empowering farmers in producing and/or selecting seed varieties that are adapted to their farming environments.

According to CIAT's (2003) report, there are a number ways for enhancing the quality of seeds used by small farmers. Notable among others are: by training men and women farmers in the planning, selection, handling and storage techniques necessary to produce good quality seeds on their own farms; by encouraging farmers to make their own selection of good quality seeds from their traditional varieties, multiply, properly process and store this seed, and then sell this 'improved' seed to other farmers either directly or at local markets; and by developing acceptable improved varieties through participatory national breeding programmes and production of good quality seed for distribution to limited resource farmers.

Conceptual framework: farmer participatory research

The traditional top-down, prescriptive approaches to agricultural research and extension has heavily been blamed for the low up-take of agricultural technologies and very often for the development of technologies that are not appropriate to farmer needs and socio-economic and agro ecological environments. This has resulted in increasing dissatisfaction with this "transfer of technology" approach leading to researchers opting for farmer participatory research methodologies. Farmer Participatory Research (FPR) is based on the pretext that farmers are researchers in their own right and have indigenous knowledge of the local conditions (Chambers et al., 1989).

Selener (1997) argues that farmer participatory research consists of seven elements. The first element is the inclusion of resource poor farmers in making decisions about the generation of technologies that solve their felt problems. Second, farmers participate in the identification of problems, needs, opportunities, priorities, design and implementation of experiments and in the evaluation of results. Third, research is conducted in the farmer's field. Fourth researchers work and learn with farmers, facilitating and providing support. The fifth element is that FPR is based on a systems perspective that requires an understanding of the entire system. Sixth, FPR involves interdisciplinary collaboration and dialogue between farmers and agricultural and social scientists.

Finally, FPR is broad, flexible and adaptive to changes in hypotheses, needs, and local conditions over time.

Lilja et al. (2000) define five different types of participatory research based on who makes decisions in the innovative process and also the degree of farmer involvement. These include: On-farm research, is when scientists make decisions alone without organised communication with farmers but then carry out the experiments on the farmers' fields; Consultative, in which scientists make decisions alone but after organized communication with farmers; Collaborative, in which scientists and farmers jointly make decisions through organized two-way communication and no part has the right to revoke the jointly made decisions; Collegial, is where farmers make decisions with organized communication with scientists but have the right to revoke recommendations from scientists; and then Farmer experimentation in which farmers make decisions without organized communication with scientists.

Okali et al. (1994), Biggs (1995) and Selener (1997) have concluded that research that does not involve farmers as active members in the early phases runs the risk of developing technologies of little relevance and of low adoption. Also farmer innovators who experiment alone obtain lower yields and reach different conclusions due to lack of methodological consistency.

RESEARCH METHODS

Description of study site

Zvishavane district roughly lies in the central parts of the Zimbabwe, about 150 km from the second largest city of Bulawayo to the North-East. It is characterized by low rainfall (below 450 mm annually), and poor soil dominated by sandy to sandy-loams. The majority of the farmers are resource poor smallholder farmers who mainly produce maize for subsistence purposes with barely any excess for sale. Two types of smallholder farmers are found in Zvishavane district: the traditional communal area farmers who have been in the district for many years; and newly resettled farmers who migrated from other districts. Besides farming, people also derive their livelihoods from illegal gold mining and employment in the local gold and platinum mines resulting in acute shortages of agricultural labour during peak periods. This set up has also resulted in farmers with different wealth statuses – the better off illegal gold miners and mine employees and the worse-off small-scale farmers (mostly the elderly, the sick and child-headed households).

Data collection: farmer participatory experimentation

The research process began with key informant interviews. These interviews were non-structured and took advantage of the use of open-ended questions to get a variety of information about the agricultural systems in the study area and about maize seed systems and practices. The key informants included agricultural extension workers, representatives of farmer organizations, administrative leaders, rural agro-dealers supplying seed to farmers, and representatives of non-governmental organizations working in the area.

Information obtained from these key informants was used to guide the development of a Focus Group Discussions (FGD) ques-

tion checklist to be used with farmers. The FGDs were carried out with 90 farmers in group sizes of 15. The following are the major exercises that were carried out during the FGDs:

- i) Introduction of the research to farmers and elicitation of their general views about the research.
- ii) Farmer identification of the maize seed problems that they have in the area.
- iii) Farmer participatory identification of the research objectives, including the varieties to be evaluated and the parameters to be considered during evaluation.

During this process, farmers were first asked to name the maize varieties that they know and then to choose those they want included in the trials. For the varieties recommended for experimentation, farmers developed a localised list of the criteria they use when selecting maize seed varieties. They were then tasked to give scores to each of the maize seed varieties based on these criteria performance. The scores depended on the farmers' past experiences with the varieties performance against each of the criteria. Farmers and researchers then discussed results of the scoring process. The minimum score was 1 and the maximum 5.

- i) Farmer participatory designing of experimentation including plot sizes, treatments, replications etc;
- ii) Wealth ranking and participatory identification of farmers to host the trials;
- iii) Farmer participatory establishment of the roles of researchers and those of farmers hosting the trials and on the general management of the trials.

A total of 6 maize seed varieties were chosen for inclusion in the trials. The agreed plot size per trial was 18 X 10 m (each variety being allocated 3 X 10 m). Farmers were also assisted in identifying wealth-ranking categories using their local definitions of wealth. Three categories of farmers were identified and grouped according to their wealth statuses. From these categories stratified sampling procedures were applied to select twenty farmers from each of the categories to come up with 60 farmers to host the trials. However, only 53 of these farmers provided the data that were used in this study. The other seven farmers withdrew from the trials for various reasons. The general management of the plots was according to farmer practice but farmers had to keep strict records of all the practices they carried out on their plots.

Data analysis: stochastic dominance analysis

An economic analysis was carried out to assess the relative performances of maize varieties using stochastic budgeting and the principles of stochastic dominance analysis. Stochastic budgets are like ordinary budgets, except that uncertainty in some variables is recognised and taken into account (Hardaker et al., 1997). Stochastic features are introduced into the budget by specifying probability distributions for selected variables, usually those judged to be most important in affecting riskiness of the selected measure of performance. Then a Monte Carlo sampling procedure is used to evaluate the budget for a sufficiently large number of scenarios. Output can be in the form of a cumulative probability distribution of the selected performance measure (gross margin in this study) or as moments of the distribution, such as mean, variance or standard deviation (Schlaifer, 1969).

Stochastic budgeting presented in this paper was carried out using computer software called @Risk. This software is an add-in to spreadsheet packages such as Lotus 123 and Microsoft Excel. @Risk uses probability distributions to describe uncertain values (such as prices and yields) in the budget. Some of the distributions from which one can choose are: the triangular, the rectangular, the

Table 1. Maize varieties known, used and recommended for experimentation by farmer.

Maize Variety	Known (If known to > 50% of farmers)	Used (If ever used by > 50% of farmers)	Recommended for evaluation trials (If yes by > 50% Farmers)
SC401	Yes	Yes	Yes
SC407	Yes	Yes	No
SC501	Yes	No	No
SC521	Yes	Yes	Yes
SC627	Yes	No	No
SC709	Yes	No	No
PAN6363	Yes	No	Yes
PAN413	Yes	Yes	No
PAN473	Yes	Yes	Yes
PAN61	Yes	No	No
PN6479	No	No	No
SC411	Yes	Yes	Yes
SC517	Yes	Yes	No
PAN35	No	No	No
PAN67	No	No	No
SC405	Yes	Yes	No
Retained Seed	Yes	Yes	Yes

normal, the beta and the gamma distributions. Most used distributions are however the normal and triangular distributions owing to the simplicity of their underlying assumptions.

Cumulative probability distributions of the performance measure resulting from stochastic budgeting can be compared using principles of first-degree stochastic dominance to find out the seed variety that dominates the others. With first degree stochastic dominance, if given two actions A and B, each with a probability distribution of outcomes, x , defined by cumulative distribution functions $F_A(x)$ and $F_B(x)$, respectively, action A dominates action B in the first degree sense if: $F_A(x) \leq F_B(x)$, for all x , with at least one strong inequality (Moss et al, 1991; Hardaker et al, 1997).

Thus first-degree stochastic dominance analysis is based on the theory of utility maximisation. In this study, the analysis takes into consideration both the magnitude and riskiness of the returns from different maize varieties and selects those varieties that give the highest returns per unit risk. These varieties have cumulative probability distribution functions (CPDFs) that, diagrammatically, lie below and to the right of the distributions of returns from other varieties and are said to dominate in the first-degree sense. The varieties that are first-degree stochastically dominant can also be referred to as being "risk efficient" in the first-degree sense. If the cumulative probability distributions for A and B cross, then first degree stochastic dominance analysis becomes inconclusive, that is, neither activity (technology) dominates and it becomes necessary to move to second degree stochastic dominance analysis (King and Robinson, 1984). In this paper, however, the analysis is only limited to first-degree stochastic dominance analysis due to the practical complexities of applying second-degree stochastic dominance analysis.

RESULTS AND DISCUSSION

Farmers' local criteria screening of maize varieties

Table 1 shows the maize seed varieties that were known

to farmers, used by farmers, and recommended for experimentation.

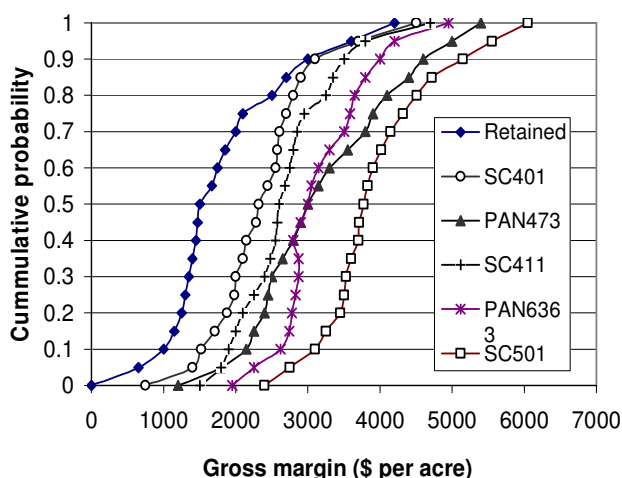
Farmers showed interest in further experimenting with those varieties they used most. Most of the varieties used by farmers were early maturing and relatively drought tolerant. About 70% of the farmers in all the focus groups reported that they still grew retained seed from past harvests and thus they recommended retained seeds for experimentation. This result is consistent with findings by Rorbach (2002) in the same district, who indicated that some more than 72% of the farmers in Zvishavane district still grew retained maize seed especially of open pollinated varieties.

In Table 2 results from farmer scoring of maize varieties are presented.

Retained seed scored very well on cost and availability. Farmers reported that they planted retained seed not because they preferred them to hybrid seed but because hybrid seeds are either not available or are not affordable. This finding supports results from studies carried out in 2001 in Kenya by Small and Jayne. Retained seed scored very poorly on yield and disease resistance. Farmers mentioned that it is vulnerable to maize streak virus and is also attacked by the maize stalk borer more than any of the hybrid varieties. There was not much variation in terms of drought tolerance and time to maturity. This is probably because all the varieties that farmers selected for experimentation (and normally use in this area) were drought tolerant and short season varieties. The total scores assigned to all varieties however do not vary much for the varieties selected for experimentation.

Table 2. Results from farmer collective scoring of selected maize varieties.

Attribute	Variety					
	SC401	SC521	PAN6363	SC411	PAN473	Retained Seed
Cost	2	2	2	2	2	5
Yield	3	4	3	3	3	1
Time to maturity	5	3	4	4	3	2
Storability	3	4	3	3	4	2
Disease resistance	3	4	4	3	3	1
Drought esistance	4	3	3	3	4	3
Availability	1	2	2	1	1	4
Average Score	21	21	21	19	20	18

**Figure 1.** CPDFs for different maize varieties.

Results of first – degree stochastic dominance analysis

Figure 1 shows the results from first-degree stochastic dominance analysis. From the diagram, it is clear that maize variety SC501 dominates other varieties in the first-degree sense of stochastic dominance analysis. This was mainly due to its yield advantage over other varieties and adaptability to a wide range of agronomic and farmer management conditions. It yielded stable returns across all experimental plots and had lower yield dispersion (as shown by the small gross margin range) than all the other varieties.

Second best risk efficient were PAN6363 and PAN437 for which first-degree stochastic dominance analysis could not produce conclusive results. The cumulative probability distribution functions for these varieties intersect and this renders first-degree stochastic dominance analysis inadequate. However it can be noted that PAN6363 is more attractive due to its smaller range of returns (as shown by a steeper cumulative probability distribution function). It thus yields more stable returns

over a wider range of agronomic and farmer management conditions than PAN473, which has a higher yield potential under good management but performs badly under poor agronomic and farmer management conditions. Choice between these two varieties is therefore likely to be influenced by the risk attitude of the farmers, which in turn is affected by farmer wealth status. Risk averse farmers who usually lie in the lower ranks of the income spectrum are more likely to choose PAN6363 with a low potential to give high returns but which yields less risky returns. On the other hand, the better-off farmers who are less risk averse would go for the more lucrative but riskier PAN437. Variety SC411 performed well in terms of stability of returns across trial sites. It is closely followed by SC401 whose returns however, vary more at higher levels.

Retained seeds produced very low yields resulting in the overall returns being low and thus the lower risk efficiency as shown by first-degree stochastic dominance analysis (the cumulative probability distribution function is the furthest to the left and is above those for all other varieties). Farmers reported that yield was also affected by diseases (mainly maize streak virus) and poor germination rates. Retained seed had the highest variation in returns depending on management and prevalence of diseases.

Conclusions and recommendations

The study has used farmer participatory research to come up with maize seed varieties that has high potential of suitability to smallholder farmers in Zvishavane district. The most striking finding of the study is the similarity of results under farmer selection of maize varieties using their own local criteria before experimentation and the results obtained using first-degree stochastic dominance analysis of experimental data. Roughly, the ranking of maize varieties by farmers was similar to that obtained through modelling. This can safely be taken to show that farmers are rational decision makers, that is, they make choices in order to maximize the returns from their pro-

duction activities. This therefore implies that it is important to incorporate farmers in experimentation especially where the experiments directly affect their livelihoods.

Results also show that smallholder, resource poor farmers are largely risk averse. This has been shown by the fact that they selected low yielding, short and medium season varieties that are resistant to both drought and diseases and left out long season varieties despite their yield advantage. It is also reflected by the fact that farmers keep part of each year's harvest for future year planting season to cushion themselves from possible future seed shortages.

The finding that farmers are optimisers point to the recommendation that researchers should work with the farmers to develop current seed systems mostly by training them on various aspects of seed production, storage and screening. Farmers should also be empowered to carryout small-scale experiments under localized conditions.

Although the results obtained from this study may have limited scope of generalizability, especially to countries other than Zimbabwe, the methodology of farmer participatory experimentation that has been used can have a great potential of applicability to most Sub-Saharan African countries with similar agricultural systems as Zimbabwe.

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