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Farmer-to-farmer transfer of new crop varieties: an empirical analysis on small farms in Uganda

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Abstract

Farmer-to-farmer transfer or dissemination of technologies is a neglected area of research even though successful diffusion of many researcher and farmer-developed technologies is highly dependent upon farmers' private initiatives. This is particularly true in many developing countries where formal market mechanisms used in dissemination are often ineffective. Successful dissemination of new technologies to marginal farmers require greater knowledge and use of indigenous dissemination methods. The determinants of farmer-to-farmer transfer of new bean varieties experimented with by small-scale farmers in Uganda are investigated. Farmers were experimenting with new varieties received through earlier on-farm trials and were transferring small quantities of grain to other farmers for experimental purposes. On-farm trials may thus be an effective, but limited method for diffusing new varieties. Factors directly associated with the transfer decision were farm size and variables identifying a willingness to experiment with new varieties. The Production risk reducing strategies of intercropping and sowing of a larger number of non-climbing bean varieties were negatively associated with the probability to transfer grain. The quantity of grain available to transfer was not associated with the transfer decision. Farmers were not transferring grain of the five varieties at different rates even though significant differences in yield were found.

1. Introduction

There is a well developed body of literature concerning technology adoption at the farm level and diffusion at the aggregate level (Feder et al., 1985). However, there is a dearth of research on farmer-to-farmer transfer and dissemination of

production technologies; an area of immense importance for the successful diffusion of technologies in many parts of the world. This is especially true in developing countries as formal markets for information on new technologies often do not exist or if available, are ineffective and beyond the financial means of many small scale farmers. Farmers in these countries have traditionally relied upon other farmers for access to new technologies, ideas, and production methods.

Traditional dissemination and transfer methods used by farmers in developing countries may

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have a far greater impact on the spread of selected technologies than either public or private firm's dissemination efforts. This is almost certainly true with regard to the dissemination of farmer-developed and selected crops, crop varieties/landraces, and livestock and farmer-developed methods used in the production of crops and livestock. Traditional dissemination methods are also believed to be of vital importance in the secondary stages of diffusion for varieties and other technologies introduced by government or private sector entities (Cromwell, 1990; Grisley, 1993; Dalrymple and Srivastava, 1991).

In a limited number of cases agricultural researchers/extensionists in developing countries have designed programs to take advantage of and build upon indigenous farmer-based technology transfer mechanisms to disseminate and speed diffusion of new technologies (Grisley and Shamambo, 1993). More efforts of this nature may be required in the near future as demand for new technologies grow. There is an urgent need to more fully understand the process of farmer-to-farmer dissemination of production technologies, ideas, and information.

In this paper, we examine this process in part by investigating the decision of small-scale farmers in Uganda to transfer or disseminate grain (seed) of new climbing bean (*Phaseolus vulgaris* L.) varieties to other farmers for purposes of experimentation. The farms studied gained access to seed of the varieties through on-farm trials which were designed to production test, but not necessarily disseminate new varieties. A by-product of the study will then be an examination of the effectiveness of using on-farm trials to disseminate new varieties of an open-pollinated crop such as beans.

2. Conceptual framework

The farmer-to-farmer technology dissemination process can be viewed as an informal market where technology passes from supplying to recipient farmers. Participation occurs in a variety of ways including visual observation, verbal exchanges, and the physical exchange of items such

as seed/grain, vegetatively propagated transplants and breeding livestock or semen and eggs of livestock.

The available supply of a technology at any point in time will be related to its tangibility. If a technology is of a physical nature, then its supply will be fixed in the short run. In contrast, the potential supply of a technological process or method that can be passed to other farmers through verbal communication will be far greater. Its supply at any point in time will only be limited by farmers' willingness to engage in communication and their ability to describe the technology to others.

In the situation examined the technology transferred is grain of five new varieties whose supplies are fixed in the short run. Allocation of available supply will depend upon uses of the grain and relative prices or utility associated with these uses. Primary uses for small quantities of grain produced by small scale farmers experimenting with new crop varieties are expected to be limited to food consumption, market sales, seed for future use, and gifts or transfers to other farmers. The supply, or allocation of grain across these four uses can be written implicitly as a function of the end-use prices: $S(P_c, P_n, P_s, P_t)$, where P_c is the price of grain used in household consumption, P_m the market price, P_s is the household seed price, and P_t is the price of grain transferred to other farmers.

An alternative way of considering P_t is to view it as the utility received when grain of a new variety is transferred to other farmers. If grain dissemination is a method of enhancing one's status within the community and status is important, then farmers may place a higher value on limited quantities of grain going for this use than its opportunity cost in other uses.

The supply relationship can be estimated if information on prices are known. For small, semi-commercial farmers, however, these prices are rarely observable other than that of market prices. Market prices for the numerous varieties of beans produced in the area studied are highly variable and are not reliable indicators of P_c , P_s , and P_t for grain of new varieties that have not been thoroughly tested in either production or

consumption and for which only limited supplies are available. Seed for beans is generally secured at consumer markets and thus has a price similar to that of grain used in consumption.

While of interest, the supply relationship for grain transfers cannot be estimated directly because of data limitations. As an alternative, we examine a set of non-price factors, some of which can be viewed as proxies for prices, that may influence grain transfers to other farmers. If grain of a variety is produced, then a farmer either does or does not pass on samples free of charge to other farmers, presumably for use as seed in experimentation. A farmer's decision to transfer grain to other farmers is thus viewed in a binary mode. In investigating this situation we use the familiar logistic modelling framework (Maddala, 1983). The model is written as:

$$\begin{aligned} \text{Ln}(P/(1-P)) \\ = b_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 \\ + B_6X_6 + B_7X_7 + B_8X_8 + B_9X_9 \\ + B_{10}X_{10} + e \end{aligned}$$

where

- X_1 total crop acres available
- X_2 percent of total crop acres intercropped
- X_3 number of non-climbing bean varieties sown
- X_4 climbing bean variety sown in 1991a (dummy variable)
- X_5 number of climbing bean varieties sown in 1991b
- X_6 kg of grain of climbing bean variety harvested in 1991b
- X_7 Urunyumba bean variety dummy variable
- X_8 Gisenyi bean variety dummy variable
- X_9 Mushingiro bean variety dummy variable
- X_{10} G13671 bean variety dummy variable
- e error term.

The dependent variable is the natural log of the probability to transfer grain (P) divided by the probability not to transfer ($1 - P$) after season 1991b, the second of two annual rainy seasons.

Formation of the model was influenced by several working hypotheses. Total crop acres, a

measure of farm size and a visible indicator of homestead wealth, and perhaps a proxy for social status and influence within the community, should be positively associated with the decision to transfer grain. Because intercropping and the sowing of a larger number of non-climbing bean varieties are normally viewed as production risk reducing strategies and engaged in by more conservative or risk averse farmers, they should be negatively associated with grain transfers. Whether or not the climbing bean variety was sown in the previous season, the number of climbing bean varieties sown, and the quantity of climbing bean grain harvested should all be positively associated with grain transfers.

The five climbing bean varieties introduced in the original on-farm trials are included as a set of dummy variables to determine if they are being disseminated at different frequencies.

3. Area of study and data used

The area studied is located in the Kabale Highlands of southwestern Uganda. Crop production occurs on both steep slopes and valley bottoms in this densely populated and mountainous area. In order to relieve the increasingly serious land shortage problem and to take advantage of more fertile soils and organic fertilizers when available, five promising climbing bean varieties were tested on-farm by the Uganda National Bean Research Program over the period 1988–90. Two of the tested varieties, Urunyumba and Gisenyi, were from Rwanda and a third, Mushingiro, was from the Kisoro area of Uganda. The varieties G2333 and G13671 are from the Americas via CIAT.

Beans are the major food and cash crop in the Kabale Highlands, but climbing varieties are rarely sown even though adjacent areas near the border with Rwanda and Rwanda itself are large producers of climbing beans. The major advantage of climbing beans is that they have the potential to yield 2 to 3 times the average yield of 700–900 kilograms per hectare realized from non-climbing varieties (Kisakye and Niringiye 1990). However, climbing beans are more costly

to produce per unit area of land because of the necessity of staking materials and higher labor requirements (Graf, 1991). In production, climbing beans are also not good substitutes for non-climbing varieties because of differences in production techniques required and because climbing beans cannot be used in the many intercropping combinations used by farmers. In consumption and marketing, climbing and non-climbing varieties are expected to be close substitutes.

The farmers studied are from a follow-up study of farmers who participated in on-farm trials for climbing beans over the period 1988–90. The sample in this study and the slightly larger group participating in the on-farm trials were not selected using random methods. However, some attempt was made to select farms for participation in the original on-farm trials on a representative basis.

4. Results and Discussion

Twenty-five of the 29 farmers surveyed were experimenting with one or more of the new climbing bean varieties in season 1991b. The four farmers that did not sow any of the new varieties were excluded in the remainder of the analysis.

An average of four varieties was sown per farm, yielding average grain production of 4.9 kg. Transfers occurred in 48% of cases in which grain was harvested, with 65% of farmers engaging in transfer activities. An average of 2.1 kg of grain was transferred to 5.3 other farmers. On an individual variety basis, average rates of transfer ranged from 1.1 to 1.6 other farmers. Fifty-four percent of grain transfers occurred in the same village in which it was produced while the remainder was transferred to farmers living in other villages. Thus there appears to be a spread of the varieties both within and across villages.

The quantity of grain received by recipient farmers ranged from 0.60 to 0.86 kg. While small, these quantities are sufficient for experimental purposes on small farms. Because of farmers' general unfamiliarity with climbing bean production technology and perceived risks, larger quantities of grain would probably not be sown even if available.

Logistic model estimates. The log-likelihood ratio test was used as a 'goodness-of-fit' test of the model. The null hypothesis is that the independent variables are irrelevant in determining the expected value of the grain transfer decision.

Table 1

Parameter estimates of a logistic model of factors influencing farmers' decision to transfer grain of new climbing bean varieties to other farmers

Variable	Parameter estimate ^a	Change in odds ^b	Variable mean
Intercept	-3.60 (1.84)		
Total crop acres available	0.13 (1.71)	1.13	6.9
Percent of crop acres intercropped	-0.02 (1.97)	0.98	51
No. non-climbing bean varieties sown	-1.05 (3.35)	0.35	2.9
Climbing bean variety sown (dummy)	1.11 (2.12)	3.03	-
No. climbing bean varieties sown	1.59 (3.00)	4.90	4.0
Kg climbing bean variety harvested	-0.0004 (0.19)	0	4.9
Urunyumba bean variety dummy ^c	-1.16 (1.62)	0	-
Gisenyi bean variety dummy	-0.74 (1.05)	0	-
Mushingiro bean variety dummy	-0.26 (0.37)	0	-
G13671 bean variety dummy	-0.58 (0.61)	0	-
log-likelihood ratio	-53		

^a *t*-Statistic in parenthesis below parameter estimate.

^b The change in odds is calculated by taking the exponential of the estimated parameter (see SPSS Version 4.0 for PCs). A value of less (greater) than one implies a decrease (increase) in the odds.

^c The left out bean variety dummy variable is G2333.

Using a chi-square statistic, the null hypothesis was rejected implying a relevance of the independent variables (Kmenta, 1986).

Four of the five non-dummy variety variables were significant (Table 1). The parameter estimates are interpreted as the change in the log of the odds for a one unit increase in the respective independent variable, holding the effect of the remaining variables constant (Studenmund and Cassidy, 1987; Pindyck and Rubinfeld, 1981). For ease in interpretation, the parameters are converted to odds from the log of the odds by taking the exponential of the estimated parameter [see SPSS Version 4.0 Manual, pp. B-39 to B-44 (SPSS Inc., Chicago, IL)]. The odds of transferring grain for changes in the independent variables are shown in Table 1 alongside the parameter estimates.

The total crop acres variable was significant and positive, indicating a direct relationship with increasing odds of transferring grain to other farmers. However, the change in odds of slightly greater than one suggests small increases in the probability to transfer for increases in farm size.

Because farm size is an easily observable variable when designing a seed dissemination program and because others have found it important in the decision to adopt new technologies (Feder et al., 1985), its relationship with grain transfers was investigated further. Using model estimates in calculation, the following probabilities to transfer were found (Pindyck and Ruubinfeld, 1981):

Crop acres	1	3	5	7	9	11	13	15
Probability of transferring	0.36	0.43	0.49	0.56	0.62	0.69	0.73	0.78

When a variety was sown a probability of 0.50 to transfer grain was reached well below the average farm size of 6.9 acres. Even at the smallest farm size of one acre, the probability to transfer grain was 0.36. In general these results indicate that farm size can be a useful indicator of farmers' willingness to transfer grain of new bean varieties to other farmers.

Of interest also was the related finding that acres sown to non-climbing bean varieties was highly correlated with total crop acres. The latter variable was selected for inclusion in the model because it is a better measure of overall home-

stead wealth. However, this finding does suggest that acreage in beans would also be a good indicator of farmers' willingness to transfer samples of bean grain.

The variables, percent of crop acres intercropped and number of non-climbing bean varieties sown, are partial indicators of food production and food security strategies. A greater emphasis on intercropping and the sowing of a greater number of bean varieties can be risk reducing strategies in production. The estimated parameters for these variables were significant and negative, indicating that farmers engaging in these practices are less likely to be involved in grain transfers to other farmers.

The dummy variable indicating whether the climbing bean variety was sown in the previous season and the variable for the number of climbing bean varieties (maximum of five) sown in the current season are indicators of farmers willingness to test and experiment with new varieties. The variables were both significant and with the expected positive sign. Farmers who sowed the variety the previous season and those who sowed a larger number of varieties in total showed a greater odds to transfer grain. Thus farmers who are more likely to experiment with new varieties in general are also more likely to disseminate the technology to other farmers.

The available supply of grain was not significant in explaining the probability to transfer. This result suggests that reasons for transfers may have more to do with characteristics of the farmer and his/her position in the community than with the availability of grain.

None of the varieties included in the set of varietal dummy variables were significant. Farmers were, evidently, not favoring one variety over another in the grain transfer decision. If this is the case, it could suggest that the transfer decision is not heavily influenced by yield performance; a somewhat surprising result given that significant variability in yield was found across varieties. It would normally be expected that superior and poorly performing varieties would not be transferred at the same rate.

Another reason for this finding could be that the demand side of the transfer market is active

in influencing the dissemination of grain. Farmers receiving grain of new varieties may be actively requesting samples of all varieties instead of passively accepting only varieties that were indicated to be superior performers. This may suggest a strong preference by farmers to test and determine the performance of crop varieties themselves.

A second reason for the above finding could be that demand for new varieties for experimental purposes was high and that available supplies of heavier yielding varieties were quickly exhausted. Recipient farmers may have been willing to accept grain of any new variety for purposes of experimentation.

The variable, age of the head of household, was included in preliminary versions of the model. Older farmers with more experience were hypothesized to transfer grain of new varieties more frequently than that of younger farmers. Farmer age, however, was not found to be significant and was dropped in the results reported. Its exclusion did not alter the magnitude of the remaining coefficients.

Several other variables that are often used in adoption models and that may be important in the farmer-to-farmer transfer decision were not considered. An education variable was not included because most farmers had similar levels of formal schooling. The influence that extension workers had on the transfer decision could not be investigated because the on-farm trials were undertaken with their assistance.

A second 'goodness-of-fit' test of the model was made by comparing the model's predicted values of the grain transfer decision with actual outcomes. In the 100 cases in which a variety was produced 48 were associated with a positive transfer decision. The model predicted correctly 73% of the time when a transfer occurred and correctly 71% of the time when a transfer did not occur.

5. Summary and Conclusions

The decision of farmers in the highlands of southwestern Uganda to transfer samples of grain

of five new climbing bean varieties to other farmers for experimental purposes is investigated using a logit model. The farmers studied gained access to new varieties through earlier on-farm trials. After four to five seasons, 86% were still experimenting with the varieties and 64% were transferring an average of 2.1 kg of grain to 5.3 other farms, about half of whom lived in other villages. These results indicate that farmers will continue to experiment with new varieties introduced through on-farm trails and pass on grain produced to other farmers for purposes of experimentation.

Farm size was found to be an indicator of grain transfers. A probability of 0.50 to transfer was found at a farm size of 5 acres, significantly less than the average size of 6.9 acres. Farmers that showed a greater willingness to experiment with new varieties were also found to have a higher probability to transfer grain to other farmers. Risk reducing strategies in production such as intercropping and the sowing of a greater number of non-climbing bean varieties, an important food and cash crop in the area studied, were negatively related to the probability to transfer. This result may suggest that more risk averse farmers are more reluctant to transfer grain to other farmers; a finding that is in general agreement with studies examining the relationship between risk aversion and adoption of technology (Antle and Crissman, 1992).

The quantity of grain available was not associated with the decision to transfer, suggesting that willingness to transfer had more to do with other factors such as characteristics of the farmer and his/her social position. In transfer, farms did not give preference across the five varieties even though significant differences in yield performance were found. This finding may result from social benefits that farmers receive from transferring grain in general or, alternatively, it may suggest a strong demand for grain of new varieties from other farmers for experimental purposes irrespective of varietal performance.

The general finding that farmers are willing to undertake experimentation with new varieties and make the technology available to other farmers implies that they may be ideal partners in schemes

to disseminate selected agricultural technologies. More research is needed in this important area in developing countries if technologies that do not easily lend themselves to formal market delivery mechanisms are to be disseminated and diffused. Included in this category are technologies that rely on cultural practices such as integrated pest and soil management and technologies identified by new varieties of open-pollinated crops and crops that rely upon vegetative propagation for reproduction.

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