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A NON-MARKET DISTRIBUTION OF CARIOCA BEAN SEED IN ZAMBIA: AN ANALYSIS OF ITS ADOPTION AND DIFFUSION

W Grisley and M Shamambo

INTRODUCTION

A theme common to national bean research programs in Sub-Saharan Africa is the strategy to increase bean productivity through the release of high-yielding cultivars. A question of central concern is how farmers will gain access to the seed of these new cultivars. In Sub-Saharan Africa there are no public or private sector firms that have been successful in the production and distribution of bean seed of either currently used or new cultivars.

The magnitude of the seed problem is potentially large as over 2.8 million hectares of beans were produced in Eastern and Southern Africa by 1988 (Grisley, 1990a). In the near term, seed firms cannot be expected to supply the necessary quantities of seed. Non-market solutions to the seed distribution problem may be required to insure that seed of newly released cultivars is made available to farmers. Once in farmers' hands, seed of preferred new cultivars would be maintained and spread through person-to-person exchanges and local markets, just as seed of currently used cultivars is maintained and spread (Grisley, 1990b). Subsequent redistribution of new cultivar seed on a seasonal basis would thus not be necessary.

The benefits of non-market approaches to seed distribution could be increased if seed were distributed to farmers who had a high propensity to adopt and an ability to retain seed supplies. However, there is little research evidence in Sub-Saharan Africa that identify farmers with these characteristics. This issue is investigated in this paper from a sample of farmers in the Serenje District of Zambia who participated in a non-market seed distribution scheme for the newly released Carioca bean cultivar.

The results learned in this study should be of use to bean researchers and policy makers in bean producing areas of Sub-Saharan Africa in the development of policies for the release and distribution of new bean cultivars. They may also have application in the release and distribution of seed of other legume food crops.

AREA OF STUDY AND RESEARCH METHODS

The Carioca bean cultivar, which originally came from Brazil, was approved for release in Zambia in 1984 after proving to be a high yielder (Bezuneh & Olsen, 1990 and Mulenga & Hopkinson, 1987). The principal reasons for the research success of Carioca are its tolerance to acid soils which are common throughout the major bean producing areas of Zambia, its tolerance to important viral and fungal diseases and its favorable response to fertilizer applications.

In 1986, 400 households in the North-Western and Central Provinces were each given two kilograms of Carioca bean seed for planting. After the 1988/89 season, 64 of the households in the Serenje District of the Central Province were selected for further study to determine the extent of adoption.

Tabular and linear correlation methods are used to identify characteristics of the

households and farms studied and the extent of adoption and diffusion. Multiple regression techniques are used to investigate the adoption decision. Because the adoption decision variable is binary, taking a value of one if adoption occurs by the 1988/89 season and zero otherwise, a logit model is used (Maddala, 1983:22). The estimated logit model for the i^{th} observation is

$$\ln(P_i/(1-P_i)) = b_o + b_1X_{1i} + b_2X_{2i} + b_3X_{3i} + b_4X_{4i} + b_5X_{5i} + b_6X_{6i} + b_7X_{7i} + b_8X_{8i} + b_9X_{9i} + b_{10}X_{10i} + u_i$$

where:
- P = probability of adoption
- X_1 = age of head of the household
- X_2 = head of the household's education in years
- X_3 = number of people living in household
- X_4 = number of bean varieties planted in 1986/87
- X_5 = initial lima in beans in 1986/87
- X_6 = lima in cultivated crops in 1988/89
- X_7 = lima in local maize in 1988/89
- X_8 = average number of years fields cultivated
- X_9 = number of cattle owned in 1988/89
- X_{10} = number of bags of maize to be sold in 1988/89
- u = error term.

The model was estimated using maximum likelihood methods and LimDep software (Greene, 1988).

RESULTS

Characteristics of the households studied are recorded in Table 1. Three years after the seed distribution, 59 of the 64 farmers were planting beans with 35 planting Carioca along with local cultivars and 24 planting only local cultivars.

Household family size averaged 6.4 persons with 3.7 being adults and 2.7 children. Households planting Carioca had a larger number of adult members and fewer children than those not planting. The average age of the head of the household (usually male) was 45 with the age of those planting Carioca being slightly above the overall average. Formal education of the head of the household averaged 3.3 years. Farmers not planting Carioca tended to have a higher level of formal education than those planting Carioca.

Land in cultivated crops ranged from 2.50 to 31.25 lima (0.25 hectare) with an average of 13.10 lima. Households that planted Carioca in 1988/89 had a larger cultivated area by an average of 4 lima than those who did not plant. Crop production was diverse with a total of 11 or more crops being planted. Hybrid maize production accounted for 6.6 lima, or 50% of the total area cropped. The next most important crops in terms of percentage of land area were sweet potato (9.9%), millet (9.2%), and beans (8.6%). Notable differences between farmers planting and not planting Carioca by the 1988/89 season were that those in the former group had larger areas in beans, local maize, millet, sweet potato, and cassava.

Farmers in the study area normally fallow fields when soil fertility levels drop. The average number of years that households have been cultivating their cropped areas was 12 years. Households not planting Carioca had a higher average at 14 years. Average distance from homestead to cropped areas was 1.2 kilometers, with those planting Carioca having a shorter distance to their fields by 0.5 kilometers. The number of cattle owned was low

Table 1
Household and farm characteristics of Carioca bean cultivar adopters and non-adopters from a survey of farmers in the Serenje District of Zambia in 1989

Variable	Carioca		
	Adopters	Non-adopters	Mean
Number of farmers	35	24	64
Head of household age	46	42	45
Head of household educa. (yrs)	2.6	4.0	3.3
Adults in household	3.5	4.0	3.7
Children in household	2.7	2.3	2.7
Lima (0.25 ha) of land in:			
Hybrid maize	6.9	6.7	6.6
Local maize	1.0	0.6	0.8
Bean	1.6	0.7	1.1
Millet	1.5	0.8	1.2
Sorghum	0.4	0.3	0.4
Groundnut	0.6	0.3	0.4
Soybean	0.2	0.1	0.2
Sweet potato	1.6	1.0	1.3
Irish potato	0.1	0.4	0.3
Sunflower	0.2	0.0	0.1
Cassava	0.7	0.3	0.5
Other crops	0.3	0.1	0.2
Total in crops[a]	15.1	11.2	13.1
Kilometers to fields	1.0	1.5	1.2
Aver. years cultivate fields	14	11	12
Total number of cattle	0.5	1.0	1.5
Number of oxen	0.5	0.6	0.6
Number of cows	0.1	0.2	0.5
Number of calves	0.0	0.2	0.4
Self-sufficient in maize (%)	97	95	96
Bags of maize for consumption	17	13	15
Bags of maize for marketing	57	36	45

[a] Totals may not add up because of errors in rounding.

overall with an average of 1.5 animals per farm.

Ninety-five percent of the households surveyed were self-sufficient in maize. On average, households indicated that 15 bags of maize were held in storage for home consumption, while 45 bags would be marketed from the 1988/89 season. The level of maize marketing was significantly higher for the group planting Carioca.

The average area planted to both Carioca and local bean cultivars was about 0.80 lima during the 1986/87 season and 0.70 lima for the 1988/89 season. Since farmers planting Carioca also planted beans of local varieties, the average total area in beans was approximately twice the area allocated by farmers who were not producing Carioca. Reasons for these findings are not known; either farmers planting Carioca uniformly expanded their bean area when Carioca was introduced or they normally plant a larger area in beans than those farmers not planting Carioca.

No correlation was found between the lima of Carioca and beans of local cultivars planted within season, except for the 1988/89 season, when a positive relationship was found. These results imply that farmers planting larger areas to local beans were not necessarily planting larger areas to Carioca beans. This was expected in the first season as the quantity of Carioca seed was fixed at two kilograms. However, by the 1988/89 season larger areas in Carioca were directly associated with larger areas planted in local cultivars

Farmers planting larger areas to both Carioca and local cultivars within a season also tended to plant larger areas in the following season as correlations between these variables across seasons were found to be positive and significant. The fact that similar results were found for both Carioca and local cultivars may indicate that farmers planting Carioca treated it as favorably as their local cultivars.

Even though the study was not designed to measure the diffusion of Carioca, a few indicators of diffusion are available from the survey data. In order for a "spread effect" to occur, the seed of Carioca would have to be passed beyond the original group to which seed was allocated. After the first harvest of Carioca, 41% of the farmers surveyed gave seed to relatives and neighbors and 26% sold Carioca on the market. For unexplained reasons, these percentages dropped to about 10% by the third season, about the same as that for the local bean cultivar group.

The quantity of Carioca grain sold was also small, ranging from 21 to 55 kilograms on average over the three seasons. Total market sales across for the three seasons was approximately 730 kilograms. Again, this level of sales was similar to that of the local bean cultivar group.

After the 1988/89 season, 57 of the 64 farmers surveyed indicated they knew an average of 3.7 other farmers who planted Carioca. This translates into a compound annual growth rate of approximately 49% in the number of farmers planting Carioca. To put this percentage into perspective, it would take 9.5 years for 5 000 farmers to be producing Carioca, given the starting base of 200 farmers that were originally given seed and the established adoption percentage of 55 percent after three years. However, it is not known if some of the farmers known to be planting Carioca were also in the original group of 200 farmers that were originally allocated seed.

In a follow-up visit to some of the households surveyed it was obvious that farmers planting Carioca did not have significant surpluses of seed to give away or sell. Part of the reason may have been due to the small quantity of seed initially distributed, combined with the fact that multiplication of bean seed is in general low. Crop losses due to adverse

weather and pests and the obvious need (or urge) to eat part of the harvest also contributed to seed loss. Several farmers indicated that they ate the full harvest, believing that more seed would be distributed each season. As expected, they asked for a source of the seed.

Parameter estimates of the logit model are shown in Table 2. The relationship estimated was significant as the log-likelihood ratio was significant at the 0.01 probability level. Five of the ten independent variables were significant. The estimated parameters are interpreted as the log of the odds that Carioca will be adopted by the 1988/89 season, where odds refer to the number of times the decision to adopt is made divided by the number of times it was not made.

Only two variables, lima in cultivated crops and lima in local maize varieties, were found to be significant and directly associated with an increase in the probability of adopting Carioca. The parameter for the lima in local maize variable was large, indicating a strong association with adoption. In preliminary analyses this variable was also found to be directly associated with the lima planted to millet, sorghum, and cassava. These crops, along with local maize, are traditional crops in this area.

One explanation for the above finding on the lima in local maize variable is that farmers who continue to plant traditional crops may have the skills and discipline necessary to store and to retain seed from season-to-season. Farmers who do not have these skills may be at a disadvantage when attempting to multiply and retain seed of a new crop or cultivar for future use. This may be of particular importance in this seed distribution scheme as only two kilograms of seed was allocated per farm.

The finding that larger farms have a higher probability of adopting than small farms is of interest. The reason is that this variable is easily observable when planning for a seed distribution program. The fact that larger farms have a higher propensity to adopt could be due to the availability of resources and their overall management skills. Shortage of food, which often results in the consumption of seed stocks, should not be a factor here as 97 percent of farmers were self-sufficient in maize production and significant quantities were in storage for home consumption.

The three variables found to be indirectly related to adoption were education level of the head of the household, the average number of years fields have been in continuous cultivation, and the number of cattle owned. Farmers with more education were less likely to adopt Carioca. Again, this result may be in line with the result for the local maize variable; older and more traditional farmers may have the necessary skills to retain seed for future use.

The finding that farmers who own more cattle are less likely to adopt may indicate that they put less emphasis on traditional crops such as beans. They may also have a shortage of labor for bean production as a continuous supply of labor is required for tending grazing animals.

Farmers with fields in cultivation a fewer number of years had a higher probability to adopt. Decisions to fallow may be related to a number of factors including the initial fertility level, farming practices, crops planted, availability of land, farmer perceptions of the advantages of fallowing, etc. Without further information on this variable it is difficult to interpret its parameter estimate.

The five remaining variables, age of the head of the household, number of people residing in the household, number of different bean varieties planted, initial (1986/87) lima in beans, and the number of bags of maize marketed were not found to be important in

Table 2
Parameter estimates of a logit model for predicting adoption of the Carioca bean cultivar[a]

Variable	Logit parameter	Mean of variable
Head of household age (yrs)	0.02 (0.99)[b]	44
Head of household education (yrs)	-0.39 (2.89)*	3.2
Number of people in household	-0.18 (1.09)	6.2
Number of bean cultivars planted	0.10 (0.28)	1.9
Lima in beans in 1986/87 season	0.23 (0.40)	1.7
Lima in cultivated crops in 1988/89	0.22 (2.55)*	13.5
Lima in local maize cultivar	0.90 (2.13)*	0.8
Number of years fields cultivated	-0.17 (2.36)*	12.2
Number of cattle owned	-0.53 (1.94)**	0.8
Number bags maize sold in 1988/89	0.01 (0.86)	48
Sigma	0.39	
Log-likelihood ratio	-24.9*	

[a] The logit model dependent variable takes a value of one if Carioca was planted in 1988/89 and zero otherwise

[b] t-statistics are enclosed in parentheses. Single, double, and triple asterisks indicate significance at the 0.01, 0.05, and 0.10 probability level, respectively.

explaining the probability to adopt. Nevertheless, knowledge that these variables may not be important in determining household bean cultivar adoption decisions can be of importance in a bean seed distribution program. These variables would be neutral in the determination of which households would receive seed.

Using estimates of the parameters of the logit model we can predict the probability that an individual household will be an adopter (Maddala, 1983:25). The actual number of households adopting Carioca by the third season was 35, while those not adopting totalled 24. Given the results for the logit model estimated, 31 of the 35 actual adopters were predicted to be adopters and 4 were predicted to be non-adopters. Twenty of the actual 24 non-adopters were predicted to be non-adopters and 4 were predicted to be adopters. These results imply that the set of household, farmer, and farm characteristics identified are reliable indicators of the probability that a farmer will adopt the Carioca bean cultivar.

The direct costs of the seed distribution program are the cost of the seed and the operating cost for its distribution. One method of estimating the seed cost is to use information on bean grain prices in local markets. In Lusaka, bean grain of the most commonly consumed cultivars was selling at Kwacha (K) 4 000 per 90 kilogram bag in early 1990. At the official exchange rate of K40 per US dollar, a kilogram of beans is US$ 1.11. At this rate, the 400 kilogram of seed distributed would cost about US$ 444.

However, the economic price for bean seed may be more than that for grain in local markets. In North America the rule-of-thumb for certified bean seed is 3.3 times the market price for grain. Recalculating the total cost of the 400 kilograms of distributed seed at this ratio would give a cost of US$ 1 465. To determine the economics of the distribution program these costs would have to be combined with the distribution costs and compared to the costs a parastatal seed company would incur for supplying a similar quantity of seed.

SUMMARY AND CONCLUSIONS

The adoption and diffusion of the Carioca bean cultivar that was distributed to 200 farmers in the Serenje District of the Central Province of Zambia are studied. Sixty four of the 200 farmers were surveyed after the 1988/89 season, three seasons after the initial distribution of Carioca bean seed. Fifty-nine of the 64 farmers were planting beans in the 1988/89 season with 35 planting both Carioca and one to four local cultivars while 24 were planting only local cultivars. For those farmers planting Carioca, the average area in Carioca was equivalent to their total area in beans of local cultivars.

After three seasons, 57 of the surveyed farmers knew of an average of 3.7 other farmers producing Carioca. These farmers probably obtained their seed from the farmers participating in the distribution scheme. The annual compound rate of growth of diffusion over the three seasons was calculated to be 49 percent.

A logit model is used to determine household, farmer, and farm characteristics associated with the decision to plant Carioca by the 1988/89 season. The characteristics total land in cultivated crops and lima (0.25 ha) in local maize were directly associated with the decision to adopt, and the variables education of the head of the household, average number of years that fields have been in continuous cultivation, and the number of cattle owned were indirectly associated with adoption. Variables that were not found to be significantly associated with the decision to adopt were age of the head of the household, number of people residing in the household, number of bean varieties planted during the initial season of the seed distribution, the lima of beans produced in the initial season, and the number of

bags of maize to be marketed in the 1988/89 season.

The Carioca bean has found a sizable niche in the surveyed farmers' bean production plans and has probably been accepted by a larger group of neighboring farmers who obtained seed directly or indirectly from the participating farmers. The non-market approach used to distribute the Carioca seed was successful, but both the adoption and diffusion rates may have been higher if a larger quantity of seed had initially been distributed to each farmer. Two kilograms of seed for beans is probably not enough to realize a multiplication of seed for future use if production disruptions occurred or quantities of the harvest were consumed by inquisitive farmers wanting to sample the new product. An initial distribution of five kilograms would probably be sufficient to achieve a fair test for the cultivar in terms of adoption and diffusion.

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