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THE ROLE OF INFORMAL SEED SYSTEMS IN DISSEMINATING MODERN VARIETIES. THE EXAMPLE OF PIGEONPEA FROM A SEMI-ARID AREA OF KENYA

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SUMMARY

In the semi-arid Mwea Division of Kenya's Eastern Province, the modern pigeonpea (*Cajanus cajan*) variety Nairobi Pigeonpea 670 (NPP 670) had become known to all farmers and was being grown by 68% of them within a period of 12 years. The only injection of this seed to the area was from a single on-farm demonstration. Three-quarters of farmers found out about the variety from observing it growing in the field, and obtained seed primarily from other farmers in the village. Factors favouring the diffusion of the variety included its attractiveness as a cash crop, the ease with which it could be distinguished from other varieties, the low seed rate, and the relative ease with which growers were able to maintain seed purity. Farmers expressed a willingness to pay for fresh seed, which suggests that more effort needs to be made to involve the formal seed sector. The present regulatory system does not favour the development of a formal supply system. NPP 670 was released more than 10 years after it was first tested.

INTRODUCTION

Farmers in Mwea Division of Mbeere District recognize the medium-duration modern pigeonpea (*Cajanus cajan*) variety NPP 670 as an important cash crop (Le Roi, 1997). This is confirmed by the remarkable diffusion of the variety in the past decade. Apart from an initial injection of seed for a single on-farm trial conducted by the University of Nairobi in 1986, and the sale of seed from this trial to other interested farmers by the government extension service in 1987, there was no other external seed intervention.

Despite the considerable research investments made in developing modern varieties of small grain crops, there are few effective distribution channels for the seed. One obvious reason is the limited reach of the formal seed sector in developing countries. Even where such a sector exists, it shows there is little interest in marketing seed of small grains. In traditional farming systems, farmers tend to grow a wide range of crops and varieties to offset the risk of crop failure. This diversity makes it expensive for the formal sector to determine and provide the seeds farmers actually want. There is a perception that few farmers are willing

to pay more than a small premium for purchased seed when, instead, they can save their own seed. The exception to this is hybrid seed, predominantly maize, for which there is a strong incentive for farmers to acquire fresh seed, as the yield loss from recycling hybrid seed can be substantial.

What can be done at the local level to ensure that seed of modern varieties reaches farmers? There are several positive examples of seed diffusion of modern varieties from farmer to farmer. Witcombe *et al.* (1999) found that, in just two years, seed of an introduced rice variety that had been selected by farmers through participatory varietal selection had spread from 3 to 41 villages in western India. In Rwanda, Sperling and Loevinsohn (1993) found that introduced bean varieties disseminated widely from one farmer to another, having been sold initially in small quantities in local markets. Non-governmental organizations have been very active in setting up community seed schemes to multiply seed at the local level for distribution to farmers. A common feature of these schemes is the importance of informal farmer-to-farmer seed diffusion after the initial injection of introduced seed.

Apart from an external source of seed, and the farmers' wish to grow a crop with characteristics favourable from the consumer and agronomic points of view embodied in the seed, two further factors have been highlighted in the success of informal seed diffusion mechanisms. These are the existence of functioning small-farmer exchange systems that do not depend on links with the wider economy, and the willingness of key individuals to play a leading role in informal seed diffusion (Cromwell, 1990; Almekinders *et al.*, 1994). Given the importance of informal seed diffusion mechanisms for small grains, it is important to understand how such systems operate, and how they can be used more effectively.

In this paper the authors report on a study of seed diffusion of the modern pigeonpea variety NPP 670 in eastern Kenya, and make recommendations on how the research system can use the informal seed system to disseminate seed of modern varieties.

MATERIALS AND METHODS

The study area and farmer selection

The study was conducted in Karaba, Riakanau and Wachoro, sub-locations in Mwea Division of Mbeere District in Kenya's Eastern Province. Farmers in this area come from two major ethnic groups, the Kikuyu and the Kamba. They were settled on 10-acre sub-divisions in the area in the late 1950's. All three sub-locations are in the agro-ecological zone classified as marginal cotton transitioning to livestock-millet (Lower Midlands 4/5) (Jaetzold and Schmidt, 1983). The area has a bimodal rainfall regime with a short rainy season from October-December, followed by the long rains from March-June. Riakanau is less accessible to the main marketing centre at Makutano (Embu junction off the main Nairobi-Nyeri Road), than are the other two sub-locations.

Table 1. Sampling scheme for selecting farmers to be interviewed.

	Sub-locations			Total
	Karaba	Riakanau	Wachoro	
Total number of villages	14	12	9	35
Estimated total number of farm households	1400	1500	800	3700
Number of villages selected	7	6	5	18
Total number of villages selected	670	703	367	1740
Number of farmers interviewed from selected villages	70	60	50	180

A combination of Participatory Rural Appraisal (PRA) techniques and a formal questionnaire were used to develop an understanding of the local cropping system and to collect quantifiable information on the diffusion of NPP 670. The questionnaire was developed, tested and implemented with 180 farmers selected by use of a stratified random sampling scheme. Stratification was by sub-location and village within sub-location. A list of farm households from the 18 selected villages was made with the help of the local authorities, and verified in meetings convened by assistant chiefs from the respective sub-locations. Ten farmers from each of the selected villages were chosen at random for the seed study (Table 1). Whenever farmers indicated that they were growing NPP 670, this was verified in the field. The variety is easily recognized.

RESULTS

Varietal characteristics, cropping systems and information flow

Local pigeonpea landraces grown by farmers in the study area, and throughout the Eastern Province, are indeterminate long-duration materials that take up to 11 months to reach maturity. The crops are planted at the beginning of the short rains and harvested after the long rains. They tend to be affected by terminal drought because the long rains are unreliable. NPP 670 is a determinate short-duration cultivar that matures and is harvested in 5–6 months and gives a second harvest approximately two months later. Being determinate, the plant is much shorter in height than the local landraces. It is also more susceptible to insect pests. Although insect pests reduce yield and grain quality both in the local landraces and NPP 670, failure to control them on NPP 670 (by using insecticides) results in almost total yield loss. In its favour, the earlier maturation of NPP 670 makes it less susceptible to terminal drought when the long-rains are poor. For farmers, there is a trade-off in terms of seed mass, pest resistance and susceptibility to fusarium wilt. This last can cause significant crop mortality. In dry years, however, the planting of short-, medium- and long-duration varieties is a useful strategy to avoid the risk of total crop failure. Farmers can also obtain a higher price for pigeonpea grain from the earlier-maturing material available before the main pigeonpea harvest.

Table 2. Most important characteristics of pigeonpea varieties grown by farmers

Variety (n)	Percentage of farmers reporting characteristics				
	Early Maturity	High yield	Good for intercropping	Good for firewood	Insect pest tolerance
Githwariga (67)	3	91	74	35	82
Kimeru (31)	44	96	71	27	77
Kionza (70)	7	100	67	37	83
Mwiyumbi (61)	5	98	52	27	55
NPP 670 (143)	100	99	38	2	4

Local landraces are sown in widely spaced (>5m) lines with several lines of cereals, predominantly maize, planted between the pigeonpea lines. NPP 670 is planted in alternate rows with cereals. The latter system results in a much higher planting density in the short rainy period. By the time of the long rains there is total groundcover. This precludes inter-planting during this second rainy season. The wider spacing of the local landraces means that they can be inter-planted during the long-rains. Early-maturing beans are favoured as the intercrop during this time when temperatures are cooler.

Farmers identified nineteen different pigeonpea varieties, but only NPP 670 was known to all of them. The variety was universally referred to as *Katumani* (the name of the National Dryland Farming Research Centre) and has become synonymous with early maturity. This variety had been grown at some time by 79% of the 180 farmers interviewed but, in the 1997–98 season, it had been planted by only 68% of them. In comparison, the most commonly mentioned local varieties *Githwariga, Kimeru, Kionza*, and *Mwiyumbi*, were known by 44% or less of the farmers. Through PRA, some of the positive characteristics associated with pigeonpea varieties were identified. They included early maturity, high yield, suitability for inter-cropping, contribution of stalks as firewood, and tolerance of insect pests. The results from the formal survey confirmed that NPP 670 was earlier maturing but inferior for characteristics other than yield which was comparable with other varieties (Table 2).

Given the higher standard of management required to cultivate NPP 670, the survey also examined where farmers had obtained information about the variety. The results are presented in Table 3. Of the farmers growing NPP 670, 75% first learnt about it from seeing it growing in the field, and the remaining 25% heard about it before they saw it.

Although extension services played a role in the dissemination of information, by far the most important means was visual observation of the crop being grown by other farmers in the village. The majority of farmers (69%) started growing NPP 670 in the season immediately following their first encounter with the variety (six months later). The mode of learning about the crop did not influence the time taken for its adoption by farmers.

Table 3. Sources of information on NPP 670 pigeonpea.

Sources of information for NPP 670	Number (and percentage) of farmers by learning method	
	Hearing	Seeing
Farmer in village	19 (44)	68 (53)
Farmer outside village	3 (7)	43 (34)
Relative in village	0	8 (6)
Relative outside village	0	3 (2)
Extension	21 (49)	6 (5)
Total	43 (100)	128 (100)
Percentage by learning method	25	75

Seed supply

That farmers were able to start growing NPP 670 so soon after being exposed to the variety, suggested that seed was not a major constraint although the actual amount planted by each farmer was less than 2 kg. The most important source for seed of both local pigeonpea and NPP 670 was other farmers, including relatives. This source was more important than the combined sources of markets, shops and extension (Table 4). Farmers who obtained seed from other farmers did so mainly within rather than from outside the village. Open-air grain markets were a more important source of local pigeonpea than of NPP 670 seed, but relatives were a more important source of first-time acquisition of local pigeonpea seed than they were in first acquisition of NPP 670 (29 and 13% respectively).

Farmers were asked if they had purchased or been given seed (Table 5). It appeared that when a farmer started growing a local pigeonpea variety the seed was usually provided as a gift. In the case of NPP 670, however, most farmers purchased their first seed. The willingness of farmers to purchase NPP 670 even for their first acquisition suggests that a formal seed supply system might be appropriate provided that there is a widespread promotional effort to expose farmers to a new variety.

Table 4. Number (and percentage) of farmers acquiring local and NPP 670 pigeonpea seed from different sources for the first and most recent occasions.

Source of seed	Local variety		NPP 670	
	First time	Most recent time	First time	Most recent time
Open air market	60 (34)	61 (47)	19 (13)	12 (22)
Other farmers in village	42 (24)	34 (26)	54 (38)	21 (38)
Other farmers outside village	17 (10)	14 (11)	23 (16)	12 (22)
Relatives in village	35 (20)	12 (9)	12 (9)	1 (2)
Relatives outside village	16 (9)	6 (5)	5 (3)	2 (4)
Shops	7 (4)	2 (2)	4 (3)	1 (2)
Extension	0	0	19 (13)	5 (9)
Others	0	2 (2)	6 (4)	1 (2)
Total	177 (101)[1]	131 (102)	142 (100)	55 (101)

[1] Percentages do not add to 100 due to rounding-up errors

Table 5. Proportion (%) of farmers who purchased local and NPP 670 seed from other farmers as opposed to being given free gifts of the same.

Sources	Local pigeonpea		NPP 670	
	First time	Second time	First time	Second time
Other farmers	25	49	77	79
Relatives	5	11	24	33

It is fair to conclude that access to seed and the supply thereof were not significant constraints limiting the adoption of NPP 670 for most farmers. However, farmers who did not plant NPP 670 immediately after learning about it cited lack of seed (29%), lack of confidence in the variety (12%), lack of money to buy seed (10%), and lack of money to purchase chemicals (10%) as major constraints.

Only 38% of farmers had acquired NPP 670 seed for a second time, and the reasons for so doing were given as seed loss due to drought (46%) and household consumption as food (28%), and to renew seed (24%) (Table 6). Through regression, and based on a *t*-test of the coefficients from a logit model, it was found that female farmers were less likely to lose seed through household consumption than their male counterparts ($P<0.1$).

Farmers are more likely to replace seed of local pigeonpea varieties than of NPP 670. This is partly explained by the wide range of local varieties and farmers' longer experience growing them, but it is also influenced by susceptibility to loss. For both local and NPP 670 seed, drought was the most important reason for acquiring seed from sources outside the farm, although the percentage of farmers acquiring the former (74%) was higher than for NPP 670 (46%). Second-time seed acquisition from outside-farm sources for both local and NPP 670 pigeonpea peaked in 1997, after a major drought in the previous season.

Two characteristics of the new variety contributed to its successful diffusion through the informal seed system. First, NPP 670 stands a better chance of escaping the effects of terminal drought because it matures earlier than the local

Table 6. Reasons for second time seed acquisition from sources outside the farms.

Reason for 2nd time acquisition	Frequency (percentage)	
	Local pigeonpea (n = 122)	NPP 670 (n = 54)
Lost seed in drought	90 (74)	25 (46)
Renew seed	15 (12)	15 (28)
Seed consumed by family	17 (14)	13 (24)
Seed destroyed by pests	0	1 (2)
Total acquiring by variety	122 (68)	54 (30)

n = number of farmers.

Table 7. Other farmers and market as sources of pure seed of NPP 670.

Sources	% of farmers reporting seed as pure the first time of acquisition	% of farmers reporting seed as pure the second time of acquisition
Other farmers and relatives	88 (n = 94)	72 (n = 36)
Market	68 (n = 22)	77 (n = 13)

n = number of farmers

varieties, and secondly there was minimal deterioration in purity, again because of its earlier maturity.

The variation in mean quantities of NPP 670 seed acquired per farmer from sources outside the farm was not significant and mean amounts acquired at the time of first and most recent acquisitions, ranged from 1.1 to 1.6 and from 1.3 to 2.0 kg respectively. The mean amount of seed purchased per farmer at the time of first acquisition was 1.8 kg, compared with the smaller amount of 1.2 kg that was donated. The most recent time that farmers had acquired seed, mean quantities were 2 kg and 1.4 kg for purchased and gift seed respectively.

Farmers appreciated the value of fresh seed and many expressed an interest in the possibility of formalized seed supply. Eighty percent of farmers stated that they would be willing to pay twice the grain price for pure seed. Of these, 42% stated that they would purchase seed every year, and 33% said that they would do so every other year. There is evidence that seed purity has declined over time. Up to 20% out-crossing can occur due to cross-pollination by insects.

With respect to the quality of NPP seed acquired from the most important sources, farmers relied more on other farmers than on markets for first time acquisition of pure seed. When they acquired NPP seed for a second time, however, they found that there was little difference in quality of seed whether it had been acquired from the market or from relatives (Table 7).

About 60% of farmers in the sub-locations of Karaba, Riakanau and Wachoro have supplied NPP 670 seed to at least one other farmer. The three years in which farmers provided the most seed to other farmers, and the amounts involved, were documented. Of 83 farmers who provided an estimated 470 kg of NPP 670 seed to 311 farmers in three years, nine (11% of total) provided 40% of the total seed to 37% of the farmers. Thirty-four percent of the seed came from Karaba, 15% from Riakanau, and 51% from Wachoro.

Of the seven farmers who provided the highest amounts of NPP 670 seed, two did so in or before 1987 and the other five did so between 1987 and 1990. No farmer who adopted NPP 670 after 1993 supplied more than 10 kg of NPP 670 seed in three years. This suggests that although some farmers, especially those in Karaba and Wachoro, specialized in the provision of NPP 670 seed shortly after its introduction, the role of such 'specialists' declined quickly as the variety became more popular. Those who specialized and provided the highest amounts of NPP 670 seed were the innovators and early adopters. Even then,

the highest amount of seed provided by a single farmer over three years was only 36 kg.

It was hypothesized that the following factors influence a farmer's ability to supply seed to other farmers: age, formal education and gender of farmer; involvement in off-farm income generation; area, soil type and locality (market accessibility) of land for crops; ownership of sprayer; ownership of ox-plough; number of livestock; total family labour available; training in NPP 670; and whether or not labour was hired. Logit regression showed that the availability of hired labour and better access to pigeonpea markets had a significant and positive effect on provision of NPP 670 seed. Use of hired labour may be a good reflection of wealth (especially in this resettlement area where farm size is quite homogeneous). Karaba and Wachoro farmers (with better access to markets and hence greater incentive to grow the new variety) were more likely to supply NPP 670 seed to other farmers. None of the other factors had a significant influence on the ability to supply seed.

The successful diffusion of seed of new crop varieties depends on adequate seed selection practices. Where a new variety exhibits favourable agronomic traits it is important that its seed is selected in the field. Of 120 NPP growers who answered a question about seed selection, 92 (78%) did select for seed. Of these, 80% carried out selection in the field. The main criteria governing seed selection in the field were short plants (49%), high yield (31%) and early maturity (18%).

There was a significant and positive correlation between the farmers who selected for seed and those who had provided NPP 670 seed to at least one other farmer. Of farmers who selected for NPP 670 seed, 73% provided seed to at least one other farmer. This suggests that buyers were able to recognize farmers who practised adequate seed selection.

First-time use of NPP 670 pigeonpea seed started in 1985 and was still continuing at the time of the survey in all three sub-locations. The greatest gains in the adoption of NPP 670 occurred in 1986–87, 1990–91, 1993–94 and 1995–96. These years were preceded by drought periods that reduced the supply of local pigeonpea seed more than of NPP 670. The numbers of first time users of NPP 670 pigeonpea increased dramatically in seasons immediately following a drought because of seed loss and the desire to find varieties that were more drought-tolerant.

Approximately 60% of farmers currently grow NPP 670. Adoption and abandonment rates by locality are presented in Table 8. The most important reason for abandoning NPP 670 pigeonpea across all three localities was lack of seed. Susceptibility to field insects influenced abandonment in Karaba and Riakanau. Lack of management skills and lack of money to purchase chemicals were factors in Riakanau and Wachoro, respectively. Abandonment may have been influenced also by distance from a pigeonpea market. Riakanau was the farthest from Makutano, the most important market for NPP 670 pigeonpea (Wachoro was the closest to this major pigeonpea market as it borders on Makutano).

Table 8. Adoption and dis-adoption of NPP 670 pigeonpea.

Sublocation	Estimated total farm households	% of farmers who had planted NPP 670 before	% of farmers currently growing NPP 670	Estimated dis-adoption rate (%)	Estimated total farm households currently gowing NPP 670
Karaba (n = 70)	1400	73	60	13	840
Riakanau (n = 60)	1500	73	43	30	645
Wachoro (n = 50)	800	96	80	16	640

n = number of farmers.

DISCUSSION

Within the relatively short period of 10 years, virtually all farmers in the study area knew about NPP 670. More than three-quarters of those interviewed had grown the variety. Four varietal characteristics favoured diffusion of this seed. First, NPP 670 is easily distinguishable from local pigeonpea varieties because of its determinate growth habit, short-stature, and bold white seeds. The majority of farmers learnt about the variety after seeing it growing in fields close to where they lived. Second, the high market value of the crop, due to its attractive bold white-seeded grain, and its availability at a time before the main pigeonpea harvest. Third, the earlier maturity of the crop makes it less susceptible to terminal drought stress in an area where the long rains are unreliable, and fourth, the ease with which farmers were able to maintain seed purity. Although the earlier maturity and determinate growth habit of NPP 670 makes it much more susceptible to insect pests, this was not a major deterrent to farmers. In fact, it was clear that the diffusion of NPP 670 speeded up after drought because the local longer-duration pigeonpea varieties had been more severely affected.

In addition to the varietal characteristics that favoured diffusion, the seed system was also important. Seed diffusion was broadly based, especially after the first few years. There was little evidence that farmers sourced seed from specific farmers, and the maximum quantities sold by any one farmer were not sufficiently large that seed sales could be considered as a major source of income. This goes against the findings of Cromwell (1990) and Almekinders *et al.* (1994) who found that the existence of key individuals willing to play a leading role in informal seed diffusion was an important factor in the success of informal seed diffusion mechanisms. One reason might be that this is a resettlement area where kinship is less important. Also, because the seed quantities involved were small there was little opportunity for profit, hence little incentive for farmers to specialize. Apart from the initial injection of seed from the research system, facilitated by the extension service, neither the formal seed system nor the extension service played a big role in the diffusion process. Other factors that assisted in the rapid diffusion

were the willingness of people to pay for seed and the relatively low planting rate (<15 kg ha^{-1}).

What are the lessons to be learnt from the successful diffusion of NPP 670 through informal means? First, more and wider demonstration by research, extension and other organizations is needed. Second, formal seed supply systems could be developed if markets and regulations were appropriate. People are willing to pay for seed. This suggests that more effort needs to be made to involve the formal seed sector. An important constraint to the involvement of commercial seed companies is the stifling regulatory system that raises barriers to the dissemination of modern varieties. NPP 670 was officially released only in 1999, more than 10 years after it was first tested with farmers in the study area. Even if commercial seed companies had wanted to market seed of this variety, it would not have been legal to do so. To capitalize on the comparative advantage of smallholder farmers in growing marketable crops, it is essential to recognize that the informal seed sector has an important role to play, but that there is also need for formal seed sector intervention. This is likely to be increasingly important as quality standards demanded by end-users become more stringent.

REFERENCES

Almekinders, C. J. M., Louwaars, N. P. & de Bruijn, G. H. (1994) Local seed systems and their importance for an improved seed supply in developing countries. *Euphytica* 78:207–216.

Cromwell, E. A. (1990) Seed diffusion mechanisms in small farmer communities: Lessons from Asia, Africa and Latin America. *Agricultural Administration (Research and Extension) Network Paper No. 21, Agricultural Research and Extension Network, Overseas Development Institute.*

Jaetzold, R. & Schmidt, H. (1983) *Farm Management Handbook of Kenya Vol II. Natural Conditions and Farm Management Information. Part C, East Kenya.* Nairobi: Ministry of Agriculture.

Le Roi, A. (1997) Evaluation of the situation of pigeonpea production in the semi-arid areas of Kenya. Diplôme d'Études thesis. Gembloux: Faculté Universitaire des Sciences Agronomiques de Gembloux.

Sperling, L. & Loevinsohn, M. E. (1993) The dynamics of adoption: distribution and mortality of bean varieties among small farmers in Rwanda. *Agricultural Systems* 41:441–453.

Witcombe, J. R., Petre, R., Jones, S. & Joshi, A. (1999) Farmer participatory crop improvement. IV. The spread and impact of a rice variety identified by participatory varietal selection. *Experimental Agriculture* 35:471–487.