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Working with smallholder farmers to improve maize production and marketing in western Kenya

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Abstract

Smallhold farmers in Western Kenya face crop production and marketing constraints that bind them within a cycle of poverty. Furthermore, many "solutions" to farmers' problems are incompletely devised and tested, often lacking complete economic analyses and thorough comparison to alternative managements. SACRED-Africa leads an alliance of non-government organizations that conducts on-farm research examining eight different recommendations for maize-legume intercropping. These recommendations were generated by various research organizations working independently of one another and included include capital-intensive "Green Revolution" technologies, soil nutrient replenishment, labor-and-resource-intensive "Organic" managements, land-extensive fallows and information-intensive (technically complex) "Integrated" solutions. The trials were conducted on 140 farms during four continuous cropping seasons between February 2002 and January 2004. Technologies that involve the addition of external inputs, both mineral and organic, offer yield improvement beginning with the first growing season, unlike those that rely upon on-site biomass recycling (e.g. relay and improved fallows), although at many locations yield improvement did not justify the increased cost of larger rates of mineral fertilization. Furthermore, many of the "recommended" technologies performed poorly on many farms, suggesting that even district-level "blanket" solutions for smallholders is too coarse an outreach approach. A better approach may be to work with NGOs and farmer self-help groups to combine the better attributes of different technical options to meet their more site-specific needs. SACRED-Africa has introduced a cereal banking system to Bungoma district. These cereal banks registered 333 members who sold 4400 bags of maize to Nairobi millers between October 2003 and January 2004 for an average price of KSh 1400 per bag. These sales generated about KSh 6.2 million, with 12% required for transportation and transaction costs, resulting in an average payment of KSh 16,424 per member. In addition, the Local Cereal Banks are open to the public and sell maize in quantities ranging from 2 kg to local consumers and 10 tons to local schools and hospitals. Local sales become more important from March to May, serving as a strategic community food reserve during the so-called "hunger months". A new developmental hypothesis, referred to as the Market-Led Integration Hypothesis, provides a framework for combining stalled input technologies resulting from otherwise successful adaptive on-farm research and new market opportunities opening to smallhold farmers.

Key words: Green revolution technologies, local cereal banks, on-farm research, Zea mays

Introduction

The Market-Led Integration developmental hypothesis states that "improved profitability and access to market will motivate farmers to invest in new technology, particularly the integration of new varieties with improved soil management options". It is based in part upon the disappointing past experiences of developing and promoting seemingly appropriate food production technologies, only to have them rejected by poor, risk-adverse farmers unable or unwilling to invest in additional inputs (Fujisaka, 1993; Eicher, 1999). Basically, most farmers are aware of the technologies that raise production levels but are reluctant to invest in them unless they are assured that the resultant crop surpluses can be readily marketed (Mukhwana, 2000). But marketing maize in Western Kenya is difficult due to farmers' lack of market information, difficulty in complying with quality control standards, poor access to transportation and a host of unnecessary transaction costs (SACRED Africa, 2004). These difficulties may only be overcome through farmers' collective action.

The Setting. Western Kenya is primarily occupied by small-scale farmers, many practicing subsistence agriculture. The area receives reliable, bimodal rainfall between 1200 to 2000 mm per year but is dominated by highly weathered, nutrient-depleted soils (Sombroek *et al*., 1982). The farmers' main enterprise is maize-bean intercropping which serves as the household food supply but, in the case of good years and larger farms, is also sold through complex, and often unfair, marketing chains (Woomer *et al*., 1998).

A map of Western Kenya and a demographic summary appear in Figure 1. Note that the average farm size is only 1.5 ha, but ranges in size from about 0.3 to 6 ha for different areas of the province. The areas with the smallest farms, parts of Vihiga and Kakamega, contain populations up to 1200 persons km^{-2} (ROK, 2001), and may be considered peri-urban rather than rural and pose a unique developmental challenge beyond the scope of agricultural improvement. For

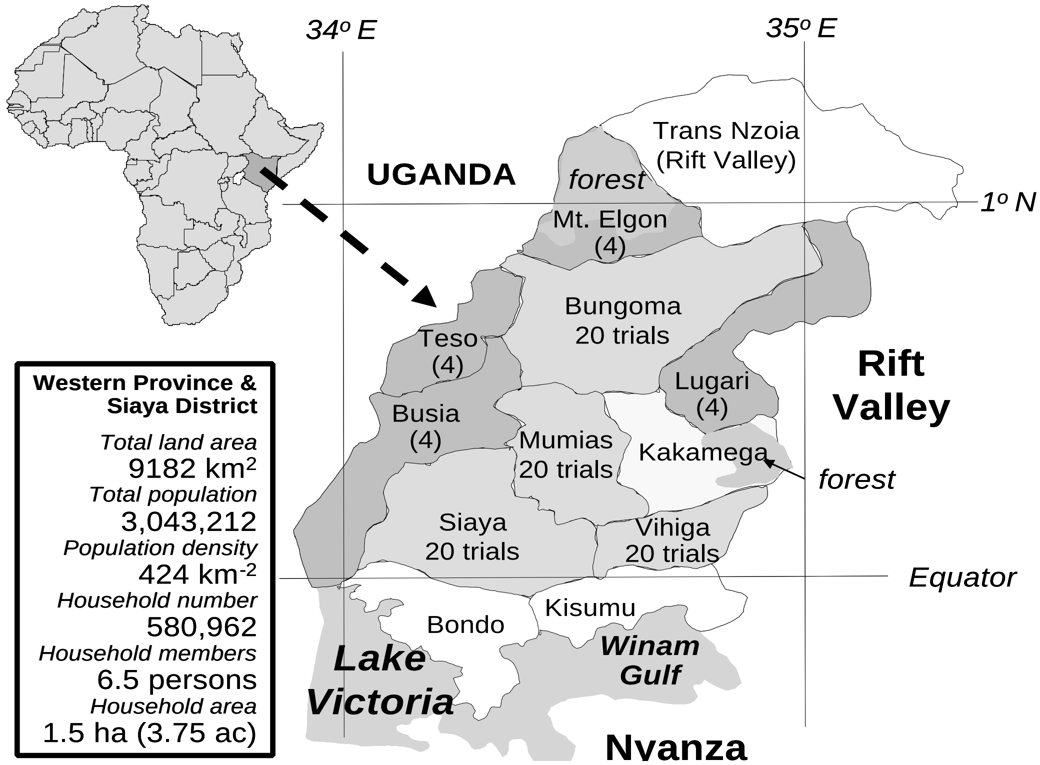

Figure 1. Western Kenya Province and Siaya District are dominated by small-scale farmers confronting a variety of crop production and marketing challenges.

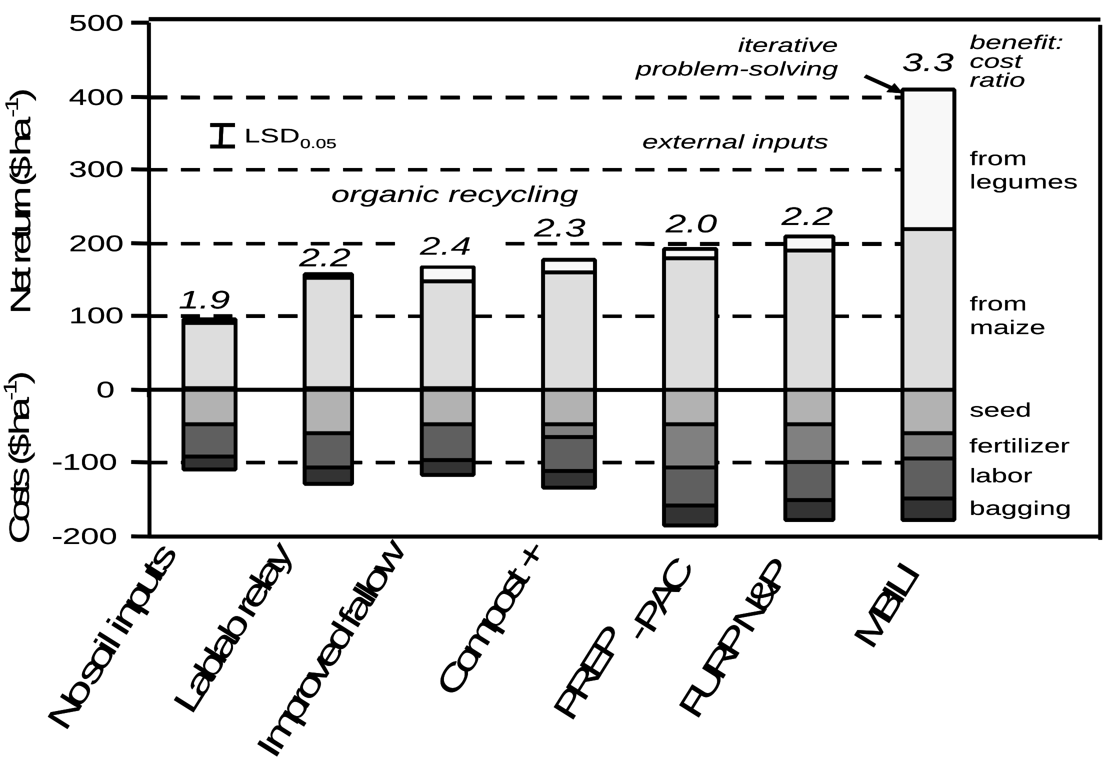

Figure 2. Average costs and cumulative net return from several Best Bet management options for maize-legume intercrops over four cropping seasons in Western Kenya.

the area as a whole, only 22% of the adult population is employed or in business, with the remainder either economically inactive and/or dependent upon family farms for their livelihood. Other market crops include tea and sugar, sold to factories, and fruit and vegetables, intended for sale at local markets. While the larger towns host active agricultural markets, the smaller local trading centers project resigned laxity and economic stagnation, in large part because scare cash is required for critical medical and educational expenses rather than being spent on daily sustenance or for improved lifestyles. Additional information about farm households in Bungoma district appears in Table 1.

Farmers' production constraints persist despite a developed understanding of them. Nitrogen and phosphorus deficiencies are widespread, resulting in average maize yields of 1.3 t ha^{-1}, about 20% of the realizable optimum. Intercropped bean yields are primarily limited by a suite of pests and diseases and yield of only 200 kg ha^{-1} are not uncommon. Most farmers do not attempt to directly control pests and diseases through the application of pesticides within the maize-bean intercrop, which places special importance upon crop resistance and rotation.

NGO-Researcher Partnership

Over the past three years, an alliance of non-government organizations has addressed food insecurity and marketing difficulties in Western Kenya and Siaya District (which technically belongs to neighboring Nyanza Province but shares the former's agroecology and marketing constraints). The core members of this NGO alliance are the Sustainable Agriculture Centre for Research Extension and Development (SACRED-Africa operating in Bungoma and Teso Districts), Resource Projects Kenya (RPK, operating in Vihiga District), Sustainable Community Oriented Development Project (SCODP, in Siaya District), Appropriate Rural Development Agriculture Programme (ARDAP, in Busia District) and the Rural Outreach Program (ROP, in Mumias-Butere District). These allied NGOs work closely with numerous community-based organizations and farmer self-help groups, forming a network that reaches thousands of farmers. Technical backstopping is provided by the Faculty of Agriculture at Moi University and the Kenya Agricultural Research Institute.

To date, this NGO alliance has examined an innovative intercropping systems (MBILI, see Woomer, 2004), compared and combined competing soil fertility management recommendations (BEST BET), developed policy recommendations for rural development (FORMAT) and established marketing channels for traditional crops (SALOP) and maize (Maize Marketing Movement). This alliance has changed common perception about the capacity and quality of on-farm research performed by NGOs, in large part because it has recruited several MSc.-level scientists to serve as coordinators and project officers over the past four years.

Breakthroughs in Soil Fertility Management

Over the past five years, SACRED-Africa and the NGO alliance have conducted on-farm research and development in soil fertility management. First, SACRED-Africa designed and field tested MBILI, an innovative maize-legume intercrop rotation that allows for the cultivation of new legumes, including groundnut, golden gram and soyabean, as intercrops (Tungani *et al.*, 2002). These legumes have greater potential to symbiotically fix atmospheric nitrogen than bean (Giller and Wilson, 1991) and command better prices within Kenyan markets. Furthermore, practicing legume intercrop rotation reduces pests and disease. MBILI was demonstrated to outperform conventional intercropping by 56% with all other management conditions held constant, in large part due to 46% greater fertilizer use efficiency and 54% understorey light penetration (Woomer *et al.*, 2003).

Several alternative "best-bet" recommendations for soil fertility management of maize-legume intercrops were examined in Western Kenya in on-farm trials over two years (see Box 1). These recommendations were generated by various research organizations working independently of one another and included include capital-intensive "Green Revolution" technologies, soil nutrient replenishment, labor-and-resource-intensive "Organic" managements, land-extensive fallows and information-intensive (technically complex) "Integrated" solutions. The trials were conducted through a network of six different Non-Governmental Organizations (NGOs) strategically located in Western and Nyanza with each responsible for 20 or 40 on-farm trials each season.

Lablab relay and crotolaria improved fallows did not improve maize yields in the first growing season (long-rains 2002), but in the following long-rains (2003) a significant ($p<0.05$) and substantial (average +1434 kg harvest ha^{-1}) gain over the no input control was realized (data not presented). In contrast, those technologies that involve the addition of external inputs, both mineral and organic, offer yield improvement beginning with the first growing season. The largest yields and greatest returns are obtained when mineral inputs were applied to soil in the FURP, PREP and MBILI treatments. Part of the economic advantage of the best two treatments (PREP and MBILI) is the significantly greater legume yields ($p<0.005$). Those technologies involving mineral inputs offer significantly greater returns than those dependent upon nutrient recycling (Figure 2), including the addition of compost, although at many locations yield improvement did not justify the increased cost of larger rates of mineral fertilization (e.g. FURP, +250 kg maize ha^{-1}). MBILI, which was originally developed from an iterative and holistic problem-solving approach to intercropping, provided the greatest economic returns in six of the seven districts, in part because it permits cultivation of higher value legumes.

The Best Bet Network documented the legitimacy and limitations of several alternative approaches to maize-legume

Table 1. Characteristics of 215 farms in Bungoma District, Western Kenya, based upon household food security status

Characteristic	Household food security status – Insecure	Marginal	Surplus	Tukey HSD P
proportion (%)	35	38	27	n.a.
farming experience (yr)	22	18	14	<0.01
farm size (ha)	2.8	2.4	3.3	0.15
maize growing area (%)	48	49	51	n.s.
standard maize-bean cropping (%)	95	98	88	n.a.
maize cultivars grown (no)	1.4	1.7	1.6	0.07
"No. 8" traditional OPV (%)	23	36	30	n.a.
later maturing hybrids (%)	87	85	86	n.a.
earlier maturing hybrids (%)	25	21	21	n.a.
new OPVs (%)	7	9	18	n.a.
maize yield expectations				
from poor season (t ha^{-1})	711	1210	1772	<0.01
from good season (t ha^{-1})	1666	2256	3022	<0.01

Table 2. Maize grain industry standards and quality before and after training in grain processing provided to Local Cereal Bank Members of the Maize Marketing Movement in 2003

	Moisture content	Diseased & discolored	Insect damaged	Broken	Foreign matter	Off color
	%					
Industry standard	<13.5	<3.0	<3.0	<2.0	<1.0	<1.0
Without training	12.4	**4.7**	**5.6**	1.0	**1.0**	0.6
After training	12.5	0.9	1.2	0.2	0.6	0.3

Table 3. Maize production costs and marketing options and returns to recommended fertilizer application in Western Kenya during the long-rains 2003

Production Costs	
Hybrid maize seed	KSh 1994 per acre
Fertilizer	KSh 2640 per acre
Labor (32 days)	KSh 2096 per acre
Processing (bags & tools)	KSh 770 per acre
Total production costs	KSh 7500 per acre
Resulting maize yield	18 bags per acre
Production costs	KSh 417 per bag
Marketing options	
Local middleman	KSh 900 per bag
Nearest NCPB	KSh 1125 per bag
Nairobi millers	KSh 1400 per bag
Net Return (after transportation)	
Local middleman	KSh 483 per bag
Nearest NCPB	KSh 628 per bag
Nairobi millers	KSh 813 per bag

Box 1. Best Bet management options of maize-legume cropping systems in Western Kenya.

FURP Recommendation. This treatment was obtained from the Fertilizer Use and Recommendation Project (FURP) of the Kenya Agricultural Research Institute (KARI, 1994). It is based upon several years of multi-location experiments using mineral inputs, relying on the use of nitrogen (N) and phosphorous bearing fertilizers at rates designed to optimize crop yields. Maize and beans are cultivated as intercrop in 37.5 cm alternating rows. Only half of the urea or CAN is applied later as side dressing. This technology recommends application of 100 kg (2 bags) DAP and 120 kg CAN applied before planting and an additional 100 kg CAN side-dressed after the second weeding, resulting in the addition of 75 kg N and 20 kg P ha^{-1} per crop. During the second growing season, only the nitrogen side-dressing is applied.

PREP Package. This recommendation results from 4 years of experimentation by Phosphate Rock Evaluation Project (PREP) at Moi University (Woomer *et al*. 2003). PREP-PAC is an integrated nutrient management package intended to ameliorate the low fertility patches symptomatic of nutrient depletion in Western Kenya. The package consists of Minjingu Phosphate Rock (MPR), urea, seeds, legume innoculant, gum arabic sticker, lime pellet and instructions, with MPR application intended to restore many years of soil phosphorous depletion. Maize and beans are cultivated as intercrop in 37.5 cm alternating rows. This management option recommends the use of 80 kg urea and 16 bags MPR per ha, equivalent to a one-time P replenishment of 100 kg ha^{-1}.

MBILI. This recommendation was obtained from SACRED Africa and is based upon a staggered intercrop row spacing and modest addition of nitrogen- and phosphorus- bearing (N&P-bearing) mineral fertilizers (DAP as a pre-plant at two 50 kg bags per ha and CAN as a side dressed application at one 50 kg bag per ha). Alternating 50 and 100 cm rows allow for the cultivation of groundnuts within a wider-row interval (Tungani *et al*., 2003).

Fortified Compost. This is a technology developed at Moi University. The technology involves utilizing low quality crop residue such as maize stover and wheat straw and the addition of small amounts of biological activators and mineral fertilizers (Ndung'u *et al*., 2003). The technology recommends the application of 2 t ha^{-1} of compost applied as a pre-plant application before the long-rains. The compost contains 2.2% N, 0.42% P and 1.4% K resulting in an addition of 44 kg N, 8.4 kg P and 28 kg K per ha and is applied during soil preparation for the long-rains (once per year).

Crotalaria Improved Fallow. This recommendation results from many years of research by the International Centre for Research in Agroforestry (Amadalo *et al*., 2003). A maize-legume intercrop follow one season's growth of *Crotalaria grahamiana* as a short-term improved fallow. After one season (usually the short-rains), crotalaria aboveground biomass is separated into two fractions, leafy twigs (fine branches) and the sticks (woody stems). The sticks are recovered and dried as cooking fuel. The leafy twigs are incorporated into the soil and, together with belowground biomass, constitute the sole inputs to the following maize-legume intercrop.

Lablab Relay Intercrop. This recommendation was obtained from KARI Legume Network and results from several years of testing various green manures and cover crops throughout Kenya (Mureithi *et al.*, 2002). *Lablab purpureus* cv. Rongai is cultivated with maize in alternating 37.5 cm rows. Following first season maize harvest, lablab remains in the field, accumulating herbaceous biomass and symbiotically fixed-nitrogen, that is then incorporated into the soil for the following maize-legume intercrop.

Farmers' Bets. The Best Bet Network reserved one of the eight management options to be assigned by the local farmers' group or collaborating NGO. Each group of twenty farmers installed a management that they believe will be compatible with their farming operations and provide a good return for their efforts as follows: Bungoma DAP applied at 85 kg ha^{-1} at planting (? 15 kg N and 17 kg P) prior to the first and third seasons, Busia DAP applied at 83 kg ha-1 (? 15 kg N and 17 kg P) prior to the first and third seasons or farmyard manure applied at 3.5 t ha^{-1} prior to the first and third seasons, Homa Bay farmyard manure applied at 6 t ha^{-1} prior to the first and third seasons, Kitale DAP applied at 167 kg ha^{-1} (? 30 kg N and 33 kg P) prior to the first and third seasons, Siaya NPKS blend at 167 kg ha-1 (? 28 kg N, 12 kg P and 28 kg K) prior to the first and third seasons, Teso Locally gathered farmyard manure applied at 4 t ha^{-1} prior to the first and third seasons, Vihiga Varies with individual farmer, a combination of mineral fertilizer and domestic compost.

intercropping but it also has quantified the failure of those technologies to serve many farmers' needs. During Best Bet activities, crop or experimental failure occurred in 31% of the trials (i.e 43 "dropout" or "hard luck" of a total 140 farms). This rate was somewhat high, considering the level of network and local NGO support to the on-farm research process, but also was dependent upon farmers' successful maize and legume cropping over four continuous seasons and confounded with crop failure due to environmental stress. In addition, some farmers' trials (3%) resulted in economic losses while only 46% of the on-farm trials produced reasonable economic returns (benefit:cost >2.0).

The Best Bet project demonstrated the NGO alliance capable of conducting large-scale, adoptive research that assists smallholders to better understand and utilize scare inputs. The NGO network was successfully backstopped by a Kenyan public university that provided analytical and other research services. The project also demonstrated that low-cost input options improve intercrop yield and economic returns under different soil and climatic conditions. On the other hand, many of the "recommended" technologies performed poorly on many farms, suggesting that even district-level "blanket" solutions for smallholders is too coarse an outreach approach. A better approach may be to work with NGOs and farmer self-help groups to combine the better attributes of different technical options to meet their more site-specific needs.

Cereal banking in Western Kenya

Cereal Banking is a new approach to marketing maize in Kenya that has been in operation in Bungoma District for the past 1½ years (SACRED Africa, 2004). In Cereal Banking, farmers form their own marketing associations to inspect, bulk, store and trade maize. This approach allows them to sell maize for top prices to larger-scale buyers, such as millers, but also to take greater control over their local food supply and sell small quantities for reasonable prices during grain shortages. Once farmers are better organized, they no longer rely upon the marketing services of local middlemen who too often purchase farmers' crops for unfairly low prices. Poor grain quality, difficulties and risks of grain storage and overly-complex marketing chains combine to result in the low prices received by too many Kenyan farmers. A group of 333 farmers belonging to five Local Cereal Banks of The Maize Marketing Movement overcame these difficulties and have now taken greater control of their own produce marketing, leading to much greater profits.

Organizing Local Cereal Banks

Each of the five Local Cereal Banks is a registered community-based organization with a constitution, elected officials and an audited bank account. SACRED-Africa, a NGO based in Bungoma, assisted in the formation of these Cereal Banks by providing training in recordkeeping, sales and marketing, and by providing local transportation, quality control services and a modest loan to commence maize trading. A bank consists of a secure warehouse, processing area and small office. Each of the Local Cereal Banks has between 40 and 100 members who pay each pay KSh 300 to register and deposit at least two 90-kg bags into the bank. Members are issued receipt books where further deposits are recorded and remain free to withdraw their deposits at any time. The three elected officials are a chairperson, treasurer and secretary, one of whom must be a woman. Cereal Bank operations are also conducted by various committee members who buy, inspect and market maize. The banks hold monthly general meetings to update members on recent stores and sales and an annual members' meeting where dividends are distributed and officers elected.

Improving Grain Quality

Kenyan white maize must meet several standards to be classified as Grade 1 and become eligible for top prices. The grain must not contain more than 13.5% moisture, 3% insect damaged or diseased grains, 2% broken grain and 1% off color grains and foreign matter. The key to meeting these standards depends upon proper shelling, drying and storage. Farmers that indiscriminately shell every cob, then dry their grain on the open ground and bag it without dusting for insects stand little chance of meeting these industry standards. On the other hand, farmers that reject diseased or insect infested cobs, dry on tarpaulins, screen away fine foreign matter when necessary, inspect grains prior to bagging and dust against weevils and borers can produce premium grade maize.

SACRED-Africa conducted a two-day training course for members of the Maize Marketing Movement that greatly improved grain quality. This course not only explained the principles of grain quality control, but also introduced and distributed simple grain processing tools to the Local Cereal Banks. Afterwards, the grain offered for sale by these Cereal Banks not only met industry standards (Table 2), but became recognized as a superior product preferred by buyers. This is because smallholders who rely upon careful hand shelling and sorting are better able to differentiate grain quality during processing than when it is machine harvested and shelled.

Reducing Storage Risks

Many initially farmers greeted cereal banking and collective grain storage with tremendous skepticism. The history of farmers' cooperatives in Kenya alone accounts for much of their suspicion, but also is the concern that poor storage conditions may result in losses, and that one insect infested bag can ruin hundreds of others. This worry is aggravated by the recent invasion of the larger grain borer, a pest of stored grain that is more difficult to control than smaller borers or weevils. SACRED-Africa assisted the Local Cereal Banks to develop pest control programs based upon prevention and treatment.

Maize is dried to about 12.5% moisture content before bagging and bags are stacked upon pallets that allow for air circulation, reducing the risks from fungal rots. Members are cautioned about shelling pest-infested cobs and advised to dust their processed maize with recommended control agents. The Cereal Banks were also supplied with dusts for use on untreated bags. Prevention alone has not proven sufficient, causing SACRED-Africa to provide fumigation services to the banks in response to pest outbreaks. Fumigation with phosphene has proven between 92% and 100% effective in the control of borers and weevils, depending upon the size and containment of the stored grain. To date, none of the maize deposited into the Cereal Banks has been lost to pests or rot.

Securing Better Markets

Cereal Banks are not dependent upon middleman buyers, but can sell large orders to wholesalers and millers, and smaller quantities to local organizations and the general public. For example, the Maize Marketing Movement sold 4400 bags of maize to Nairobi millers between October 2003 and January 2004 for an average price of KSh 1400 per bag. These sales generated about KSh 6.2 million, with 12% required for transportation and transaction costs. These sales resulted in an average payment of KSh 16,424 per member. In addition, the Local Cereal Banks are open to the public and sell quantities ranging from 2 kg to local consumers and 10 tons to local schools and hospitals. Local sales become more important from March to May, serving as a strategic community food reserve during the so-called "hunger months".

Comparing costs and returns

It is important that farmers know their production and processing costs so they may calculate their profits derived from different market prices and buyers. An example of these calculations was made based upon maize yields from 100 farms during the 2003 long-rains in western Kenya (Table 3). When the locally-recommended hybrid seed was combined with moderate fertilization (26 kg nitrogen and 8 kg phosphorus per acre), the average maize yield was 18 ninety-kilogram bags per acre (= 1620 kg). Not included in the following economic analysis is the bean intercrop, which produced less than two bags per acre and is assumed to be used by the household.

This example illustrates how farmers are able to increase their profits 68% by collectively marketing to a Nairobi miller rather than individually selling to an opportunistic middleman waiting at their farm gate! But keep in mind that these economic returns are dependent upon maize yield. When maize production declines to only 10 bags per acre, the new production cost is KSh 750 per bag and farmer's profit from sales to Nairobi millers declines by over 40%.

Marketing Lessons Learned

Several important lessons were learned by the Maize Marketing Movement. Collective action is the key to improve the market access and experience of poor farmers. Smallholders, acting as individuals, can neither produce the quantities necessary to enter the larger, more-reliable markets, nor access current information about, or transportation to those markets. Farmers themselves must form and participate in strong, local marketing associations in order to receive a fairer value for their produce. Reducing the control held by opportunistic middlemen requires that farmers develop greater market intelligence and address farming as a business. The poorest farmers risk becoming bypassed if special effort is not made to include them within local cereal banks. Ways to include the poorer members of the community include setting membership dues and minimum grain deposits very low, and returning dividends from cereal bank profits to all members.

Collective bulking and storage are essential for meeting market demand and for development of forward contracts with processors. Minimum orders with millers are about 100 tons or more, and only when several Local Cereal Banks coordinate their efforts can these size contracts be secured. Furthermore, sound storage practices allow the Local Cereal Banks to "wait out" the low prices following peak harvest in order to obtain a larger profit from their grain. Revolving credit and partial payment for deposited grain are important features within cereal banking because it provides access to capital at the farm level.

These lessons will be incorporated into the planned expansion of Cereal Banking in Western Kenya that is funded through a grant from The Rockefeller Foundation. SACRED-Africa, and its NGO partners in Mumias-Butere (Rural Outreach Program), Siaya (Siaya Community-Oriented Development Project) and Vihiga (Resource Projects Kenya), plan to increase the number of Local Cereal Banks from five to twenty, with a projected membership of over 1500. The operations of the banks in each district will vary in response to local farming opportunities. For example, the banks in Vihiga will promote and market higher-value horticultural products while those in Siaya will provide blended fertilizers specially formulated for local soil conditions. Better access to markets will accelerate the adoption of improved farming techniques in a manner that stimulates local economies and promotes employment opportunities, and cereal banks are an important component of this rural transformation.

Application of the market-led hypothesis

Which returns us to the Market-Led Integration hypothesis, and the conditions necessary for it to be fully tested. If the hypothesis is correct, members of recently-formed cereal banks should be less risk adverse and more willing to test and adapt "proven" production technologies, including newly-released, improved crop varieties (Byerlee and Eicher, 1997). This willingness is not, however, independent of the manner that the technologies are being promoted. Promotion of new technologies and products may range from passive, as with the sporadic distribution of written materials, to active, where widespread demonstrations are accompanied by field days, comprehensive information campaigns, sample product distribution and market surveys (Woomer, 2004).

This situation may be expressed as a two-by-two matrix with passive (P) and active (A) promotion undertaken among cereal bank members (M) and non-members (O) (Figure 3). We have some experience with the four "states" within this matrix. The OP approach has generally resulted in low rates of adoption in the area of soil fertility management. Particularly among the poorest farmers (e.g. FURP and PREP-PAC) although both MBILI intercropping and Lablab relay fallows were observed to move across neighboring farmers' fences (two technologies that do not necessarily involve purchased inputs). Active promotion to the general public (OA) is represented by the SCODP-FIPS approaches to fertilizer awareness and marketing, where products packaged in very small quantities were successfully marketed at local trading centers, accompanied by other free samples. It is too early to characterize the effectiveness of technical dissemination within established marketing associations (MP and MA), as the cereal banks have only been in full operation for less than one year. Some groups have, however, expressed interest in collective purchase of seed and fertilizers during the next season. But these individual "states" alone do not test the Market-Led Hypothesis, this is rather achieved by comparing farmers as they move from one state to another.

Within the promotion by membership matrix approach (Figure 3), comparing OP vs MP serves as a first approximation of the Market-Led Integration Hypothesis if market empowered farmers are indeed more eager to increase production through technology adoption. OA vs MA serves as a second test under more favorable and market-oriented extension conditions. OP vs OA and MP vs MA tests an alternative hypothesis that "immediate market access is less important than the manner and intensification in which "proven" technologies are presented to farmers". OA vs MP tests the substitution of market membership for product promotion (e.g. less intensive promotion campaigns are required among farmers organized within marketing) and OP vs MA represents the contrasting "rural transformation optima" of market-empowered farmers receiving better technical and product information. From a less theoretical perspective, these comparisons can provide insight into how much time and resources should be devoted to organizing marketing associations versus improving extension campaigns as individual components within the rural transformation process.

During the Best Bet trials of 2002 and 2003, 61 of 100 farms in western Kenya reported crop yield and production costs for all four cropping seasons. When this information was combined with processing and transportation costs, and prices offered by different buyers, the returns to different crop management and marketing strategies could be calculated. The Market-Led Integration Hypothesis implies that technology adoption by farmers undergoing the transition from subsistence farming to mixed enterprise agriculture, particularly reliance upon improved crop varieties and new soil management practices, is governed by market access that permits the sale of resulting farm surpluses. Not only must these markets exist, but farmers must be aware of and have access to them.

Maize producers in western Kenya, particularly those belonging to marketing associations, have access to three buyers; local middlemen, the National Cereals and Produce Board (NCPB) and large-scale commercial millers, with each buyer offering higher prices and requiring greater transportation costs, respectively. These producers also have different available land management options that involve the use of fertilizers and purchased seed. If one ignores that fertilizers and seeds were provided to farmers through the Best Bet Network, rather than actually purchased through farmers' decision making, and assumes that all yield was marketed through all three channels, then the comparative advantage of different production and marketing strategies may be calculated and expressed as both net returns and benefit:cost ratios (Figure 4). Clearly, economic advantages may be obtained through the purchase of farm inputs and the access to more favorable markets. Based upon net return, an average 27% and 58% increase is obtained from accessing NCPB and Nairobi markets, respectively. Returns are increased by 111% when fertilizers are applied and 235% when the MBILI intercropping "package" is adopted.

Combining the best market (Nairobi millers) and the most productive technology (MBILI intercropping), net return is increased by 474%, resulting in an additional $454 per ha per crop (note that western Kenya may produce two crops of maize per year). While this "test" of the Market-Led Integration hypothesis is incomplete because it is not based upon genuine farmer adoption, it suggests that strong incentive exists for farmers to adopt new technologies and access new markets. SACRED-Africa and our research and development partners are currently planning a more thorough test of the Maeket-Led Integration Hypothesis based upon technology adoption among members and non-members of cereal banks that are exposed to different intensities of extension support and product promotion.

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Marketing Approach	Promotional Approach	
	Passive (P)	Active (A)
Others (O) (non-members)	OP Past experience: limited adoption of purchased inputs	OA Past experience: greater adoption of strategically packaged input
Cereal Bank Members (M)	MP Limited experience Members requesting bulk purchase and credit for inputs	MA No experience: Cereal Banking has not yet been linked to promotional campaigns

Figure 3. A matrix approach toward characterizing Market -Led Integration of agricultural technologies

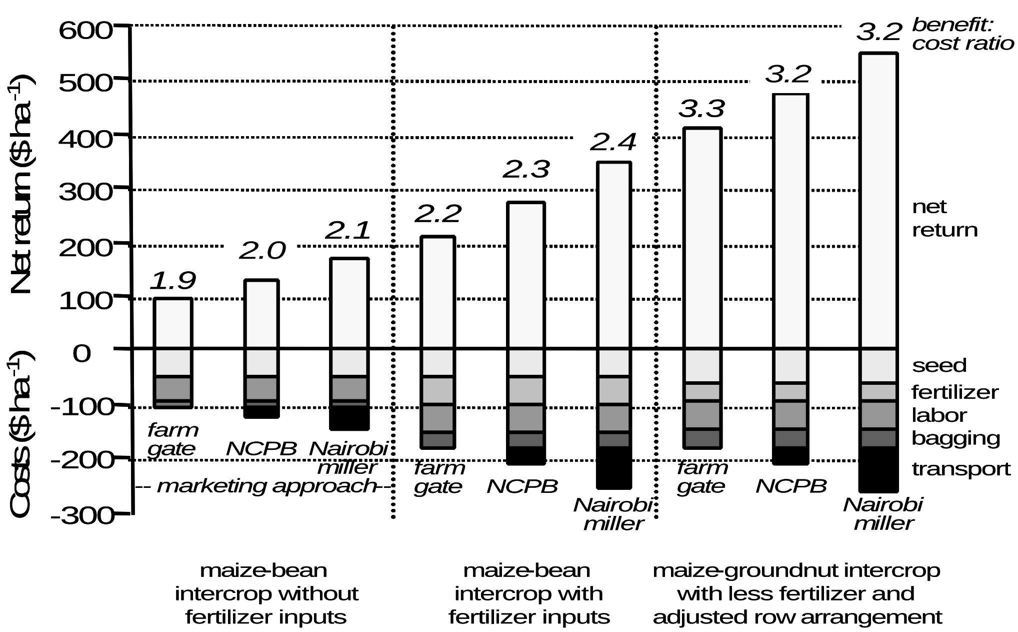

Figure 4. The comparative advantage of different production and marketing strategies expressed as both net returns and benefit: cost ratios.

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