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Recycling Hybrid Maize Varieties: Is It Backward
Practice or Innovative Response to Adverse
Conditions in Kenya?

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Recycling Hybrid Maize Varieties: Is it backward practice or innovative response to adverse conditions in Kenya?

Summary

Hybrid varieties have significantly contributed to increased maize productivity in Kenya and other Sub Saharan African SA countries. A number of factors like high costs, low price of maize grain and non-availability of preferred varieties limit access of farmers to improved maize varieties. Farmers resort to the alternative option of recycling the hybrid maize seeds. Seeds are carefully selected based on cob and grain size during or before harvest after which they are preserved. Hybrid maize varieties (HVM) developers and disseminators observe that there is a progressive yield decrease of recycling HVM and discourage farmers from recycling. The question is 'Is it uneconomical to recycle HVM or an innovation that farmers can practice?' This study was designed to evaluate the yield losses and benefits of hybrid maize recycling in Kenya. Through key informants, farmers who grew both certified seed and recycled maize were identified and randomly selected. For on farm trials (OFTs), sixty two (62) farmers who recycled hybrid maize varieties and 30 who grew certified seeds were randomly selected while for the on station trial (OST), the trial was laid out in a completely randomized block design replicated four time with plots measuring 100M square. For the OFT, two plots of 100 square meters were superimposed on farmers' fields both on recycled and fresh seed. Input and output levels in the plots were identified and valued. The results showed that the yield decreases at an increasing rate. Yield losses for Double crosses were low compared to the top crosses. The yield levels of recycled top cross reduced by 16%, 17% and 32 while that for double crosses decreased by 20%, 37% and 46% for the first, second

and third recycling generations respectively. However, positive net benefits are attained in recycling HMV. This implies that it is beneficial to recycle HMV up-to the third generation level. However, at regional and national level, food security objective is compromised. This demands that incentives to discourage farmers from recycling may be sought through development of OPVs which can be recycled if national objective of food security has to be enhanced. From the logit results the major significantly influencing factors in recycling HMs are amount of credit, fertilizer, wealth and extension contact which if addressed may discourage farmers from recycling.

Recycling Hybrid Maize Varieties: Backward practice or innovative response to adverse conditions in Kenya?

1.0. INTRODUCTION

Despite technology developers and disseminators emphasizing that hybrid maize varieties developed from inbred lines should not to be recycled (Allan 1971; Hallauer 1997; Neal 1995, Shumba 1990, Rice et al 1997), a significant portion of farmers in Kenya and other sub-Saharan African countries still practice (Heisey et al 1997; Morris et al 1999). Currently, it is estimated that about 30% of maize area in sub-Saharan Africa is planted under hybrid maize. The rest of the area is under recycled maize varieties, which include high hybrid maize varieties (HMV), local landraces (LL) and Open pollinated varieties (OPV) (Ligeyo, 1997, Onyango 1997 and Onyango *et al* 1998). The recycling of HMV is termed as a backward practice among technology developers and disseminators. In Kenya, depending on the price of maize grain among other factors, it is estimated that between 10-40% of farmers still recycle maize varieties and area under HMV has decreased compared to the 1992 Maize Data base survey (Hassan, 1998). According to Ochieng' and Tanga (1995) recycling leads to a yield loss of about 20% to 50%. The recycling is attributed to both socio-economic and biological factors (Morris and Rizopouluos 1999; Akulumuka *et al* 1997; Zambezi al. 1997)). These factors include; lack of cash to purchase increasing cost of certified seed, preference to specific HMVs not accessible on the market and limited knowledge on the biology of breeding (Mose *et al* 2002). For example the cost of maize seed has risen from KSh 4.40 per

kilogram in 1980 to about KSh 120.00 in 2005. Therefore with high cost of maize production one of cost reducing strategy is to use recycled seed. Farmers prefer recycling specific hybrid maize variety because of sweetness and stable yields even with sub-optimal input use (low yielding environments) (Ombakho *et al* 1998). According to Morris *et al* (1999) and Pixley and Banseger 2002) recycling of maize varieties leads to loss of hybrid vigour due to contamination, genetic drift, mutation, natural selection and segregation (Heisey *et al* 1997 and Morris *et al* 1999).

Development of maize varieties in Kenya dates back to 1950s with the first variety released in 1961 and in 1964 H611 was released (Gerhart 1975). HMs are developed from crossing pollen from male plant with female, which forms the seed with an isolation distance of not less than 200 meters to avoid adulteration. This is aimed at increasing the yields among other preferred traits embedded in the varieties. The number of varieties has increased drastically from one in 1964 to about forty in 2005. The increase could be attributed to market liberalization of the seed industry in 1994 (GoK 2002; GoK 1994 and Nyoro 1999). During this period yields were improved from 3 tons per ha to about 7 tons per ha. Varieties from bred outside Kenya came in after liberalizing maize seed sector in 1994. The objectives of the study are to: identify the criteria used to select recycled maize varieties for production; document the processing of the recycled maize varieties for growing; and assessing the profitability of growing the most recycled maize varieties. Therefore based on this understanding is it economically viable to recycle HMs?

2.0 MATERIALS AND METHODS

Conceptual Frame work

Hybrid maize was scientifically bred to reap maximum yields from F1 generations. The benefits and genetic make up and therefore vigour of the hybrids vary from variety to variety. However, with recycling the hybrid vigour is lost. Farmers who recycle forgo some benefits while on the other hand saving on some costs. Thus, farmers weigh the benefits and costs in making decisions on whether to recycle HMV or not. The decision by farmers to recycle is assumed to be rational and is driven by a number of factors which include farm, farmer and other socio-economic in nature.

Data type and sources

Data for the study was generated from farm surveys (2003) and on-farm trials (2002-2003). The survey was carried out in 2003/2004 and covered the six major maize agro-ecological zones namely; Low Tropics (LT); Moist Transitional (MT); Moist mid altitude (MM), dry transitional (DT), Dry mid transitional (DT), High tropics (HT) (Hassan, 1998). Farmers were randomly selected from a list of farm households developed at village level. Using a structured questionnaire, a total of 1800 households were randomly selected using simple random sampling technique. Data for the on-farm trials were collected from 60 sites distributed in three districts with a back-up trial at the research center. Plot sizes were 10meters by 10 meters (100m²). Agronomic and economic data were collected from the participating farmers. The data included: type and generation of variety, land preparation, time of planting and weeding, harvesting and post harvest activities including yield levels. Qualitative data on seed selection and processing by farmers were also collected. In order to

quantify benefits and costs, all inputs (seed, fertilizer, recycled HVMs, labour) and outputs (grains) were identified and quantified and prices pegged on them through a semi-structured questionnaire. Farm gate prices including transaction costs (transportation costs) were added to the purchase price. The quantification of benefits and costs was done through monitoring of all production activities, inputs and outputs that went into the two plots. This was a farmer managed trial but the design was done by research-extension team. Thus the farmer participated in all the activities of the trial including harvesting.

Data analysis

Partial budgeting and logit regression model is used to evaluate the qualitative and quantitative implications of economic use of recycling HVMs. The models were specified as shown in equations 1-3. For partial budgeting the benefits of using recycled HVMs were compared to the costs, using data of on-farm trials. The Gross benefits per hectare of product I , is defined as the yield Y_i , times price P .

$$Gross - Benefits = Y_i P_y \quad \text{Equation 1}$$

The Net benefits (NB) are defined as Gross benefits (Y_i times maize price) minus Total variable costs (TVC) which is a summation of all inputs X_i times their respective prices P_x (equation 2) (CIMMYT, 1988).

$$Net - Benefits = Y_i P_y - X_i P_x \quad \text{Equation 2}$$

The logit model was used to evaluate factors influencing incidence of growing of recycled maize varieties. Logit model is a logistic distribution bound between 0 and 1. The model was specified (Theil, 1979) and , Maddala, 1983) as shown in equation 3.

$$\log \left[\frac{\text{Prob}(\text{event})}{\text{Prob}(\text{no} - \text{event})} \right] = \mathbf{b}_0 + \mathbf{b}_1 X_1 + \dots + \mathbf{b}_k X_k \quad \text{Equation 3}$$

Where β_{is} are estimated coefficients and X_i are independent variables such as farmer and farm characteristics. The variable hypothesis and descriptions in the model are shown in

Table 1.

Table 1. Variables used in the Logit model for regression analyses of recycling HMV

| Variable name | Nature of variables | Unit | Variable description | Expected sign |
|--------------------|---------------------|--------------|--|---------------|
| Dependent | | | | |
| RecyDumy | Binary | | Adopters of grows recycled HMVs. 1=grows HMV; 0 otherwise | |
| Independent | | | | |
| Acre | Continuous | Ha. | Acreage under maize is an indicator of income source which may influence farmers to adopt pesticide use | -ve |
| YldMze | Continuous | Kg | Yield per hectares is an incentive for farmers to adopt pesticide use. | +ve |
| Herb | Continuous | Kg/ha | Amount of Herbicide though a competitor for cash was a proxy to the importance farmers attach on maize and hypothesized to negatively influence farmers to recycle | -ve |
| TotFert | Continuous | Kg/ha | Amount of fertilizer use. Farmers use less of fertilizer on recycled maize hypothesized to negatively influence farmers recycling | -ve |
| LabHa | Continuous | Hours per ha | Total of labour in maize production and it is hypothesized to positively influence farmers to adopt pesticide use | +ve |
| QtyMzeSel | Continuous | Kg/hh | Quantity of maize sold was hypothesized to negatively influence farmers recycling | -ve |
| Age | Continuous | Years | Age of household head can be a proxy to experience and was hypothesized to positively influence farmers to farmers who recycle. | +ve |
| Gender | Binary | | Gender of household head. This was dichotomous variable (1=male; 0=female), which influences access and control of capital. Hypothesized to negatively influence recycling | -ve |
| Educ | Continuous | Years | Education of household head in years. Was hypothesized to influence the farmer. More years in school meant less likely to recycle HMV | +ve |
| %TimeOnF | Continuous | % | Time on-farm of household head was an indicator of sourcing for cash to complement farm expenditures. Hypothesized to positively influence recycling | +ve |
| ExtCont | Binary | | Farmer training was hypothesized to negatively influence farmers to recycling | -ve |
| Wealth | Continuous | | Was hypothesized to negatively influence farmers recycling | +ve |

| | | | | |
|----------|------------|-------|---|-----|
| InsectHa | Continuous | Kg/ha | Quantity of insecticide per ha. On recycled maize and was hypothesized negatively influence recycling | |
| Credit | Continuous | KSh | Amount of credit hypothesized to positively influence farmers recycling | +ve |

3.0 RESULTS AND DISCUSSION

General characteristics

The general farm characteristics are shown in Table 2. The average age of farm household heads that recycle was 49.3 years while those who grow only fresh seed was 49.4 years. On the other hand the average number of years in school for those who recycles was significantly lower than those who grow fresh seed. In addition that percentage time of those farmers who recycle was significantly higher than those grow fresh. This may be attributed to engagement in off-farm income generating activities of farmers who grow fresh seed. However from the data set there was no significant difference in farm sizes of farmers who recycle and those growing fresh seed. The percentage of farmers recycling ranged from 10% to 35% in all the six maize zones in Kenya. The variability could be attributed to differences in resource base of farmers and yield potential.

Table. 2. General characteristics of Households heads who grow recycle and fresh HMV

| Variable | Recycles | | Fresh | |
|-----------------|----------|-----|-------|------|
| | Mean | Sd | Mean | sd |
| Age | 49.3 | 4.4 | 49.4 | 14.8 |
| Education years | 6.2 | 4.4 | 7.4 | 4.0 |

| | | | | |
|---------------------|------|------|------|------|
| % time on-farm | 74.1 | 36.9 | 60.5 | 38.0 |
| Distance to markets | 2.2 | 5.5 | 2.5 | 15.7 |
| Farm size | 4.5 | 3.2 | 4.4 | 3.9 |

Selection and Processing of recycled maize Seed

Farmers exert selection pressure on recycled HMVs by carefully selecting and processing seed. This contributes to reduction in yield between fresh seed and recycled HMV materials. The major sources of recycled seed were own farm crop (50%), neighbours (30%) and from the open market (20%). The seed from neighbours is either given free by neighbours or bought as a commercial crop from the market.

Farmers who select seed from own crop, did this either during harvesting of the whole field or before. For those who selected seed when harvesting the whole field, they picked good-looking big cobs and grains. Big stocky stems were a good indicator of the above-mentioned characteristics. After harvesting, the cobs were shelled and preserved using chemicals in bags a waiting planting season. Some farmers picked the seed when the maize crop had reached physiologically maturity and still in the field. They selected cobs and stored them above fireplace. This maize was then shelled just before planting. In all cases farmers shelled grains from the central part of the cob and avoided the grains from the tip and base of the crop.

Input utilization in Recycled hybrid maize in Kenya

From the survey both recycled and fresh HMV production scenarios received external inputs but at varying rates (Table 3). In most of AEZs, the seed rate was higher for the recycling

than fresh material. This could be attributed to may be due to poor germination anticipated by farmers and lower cost of the seed of recycled seed. In all cases fertilizer application was lower than the optimal rates of 120 kg per ha. For basal and 150 kg for top-dress fertilizers. The lower rates could be attributed to escalating cost of fertilizers against the relatively lower output prices. On the contrast all farmers hire in labour for both recycled and fresh HVM production.

Table 3. Input utilization in recycled and fresh HVM production in Kenya.

| Zones | Variable | Inputs and yield levels of farmers growing | | | | Zone | Inputs and yield levels of farmers growing | | | |
|-------------|-------------------------------|--|-------|------------|------|-------------|--|-------|------------|------|
| | | Recycled seed | | Fresh seed | | | Recycled seed | | Fresh seed | |
| | | Mean | SE | Mean | SE | | Mean | SE | Mean | SE |
| MT n=418 | Seed rate/ha. | 30.28 | 1.06 | 15.65 | 1.06 | DT n=100 | 28.8 | 3.85 | 24.72 | 5.41 |
| | Total fertilizer rate/ha | 82.14 | 12.31 | 191.6 | 25.3 | | 81.11 | 31.61 | 147.7 | 42.6 |
| | Hired labour hours/ha | 51.63 | 17.7 | 134.18 | 23.6 | | 641.65 | 148.9 | 1975 | 546 |
| | Total labour in maize prod/ha | 409.44 | 58.27 | 434.63 | 45.1 | | 2608 | 388.1 | 6014 | 1292 |
| | Maximum maize yield kg/ha | 5058 | 810.9 | 7204.9 | 700 | | 3314.3 | 740.6 | 13110 | 4983 |
| | Minimum maize yield kg/ha | 2798.3 | 60.46 | 464.73 | 119 | | 462.04 | 83.2 | 3342 | 900 |
| LT n=300 | Seed rate/ha. | 9.69 | 0.5 | 7.81 | 0.59 | DM n=100 | 28.46 | 1.52 | 22.05 | 1.83 |
| | Total fertilizer rate/ha | 11.27 | 4.47 | 40.44 | 12.5 | | 2.18 | 0.79 | 14.49 | 3.67 |
| | Hired labour hours/ha | 162.5 | 23.75 | 213.23 | 46.1 | | 202.47 | 35.81 | 305.5 | 140 |
| | Total labour in maize prod/ha | 1075.9 | 69.77 | 1241.7 | 134 | | 1425 | 105.8 | 2161 | 445 |
| | Maximum maize yield kg/ha | 2198.4 | 172.6 | 2079.9 | 239 | | 1771.9 | 102.9 | 2480 | 392 |
| | Minimum maize yield kg/ha | 511.17 | 44.9 | 571.07 | 70.7 | | 368.3 | 32.25 | 394.2 | 61.8 |
| MM n=250 | Seed rate/ha. | 21.45 | 0.7 | 16.98 | 0.85 | HT n=400 | 27.17 | 2.67 | 26.62 | 0.86 |
| | Total fertilizer rate/ha | 17.04 | 2.93 | 51.51 | 6.56 | | 167.25 | 29.96 | 228.3 | 12.6 |
| | Hired labour hours/ha | 226.18 | 35.67 | 155.06 | 40.3 | | 224.14 | 70.82 | 322.9 | 31.7 |
| | Total labour in maize prod/ha | 1483.9 | 71.29 | 1114.6 | 85.3 | | 808.72 | 170.2 | 743.7 | 67.5 |
| | Maximum maize yield kg/ha | 1826.3 | 105.4 | 2153 | 227 | | 8474 | 2193 | 6802 | 679 |
| | Minimum maize yield kg/ha | 700.52 | 49.74 | 1044.6 | 129 | | 4650.6 | 1955 | 3109 | 303 |

How much yield do farmers loose when recycling HMV?

As shown in Table 4, of all the hybrid recycled, yield losses for double crosses is lowest compared to the Top crosses. The yield levels of recycled Top cross (H614) reduced by 16%, 17% and 32 while that for double crosses (H625, H626, H627, H628) decreased by 20%, 37% and 46% for the first, second and third recycling generations respectively. The yield losses are attributed to a number of factors which include loss of hybrid vigour and sub-optimal input use of inputs (e.g. fertilizers).

Table 4. Yield losses due to recycling HMVs in Kenya.

| Variable | Generation level | | | |
|-------------------------------|------------------|----------------|----------------|----------------|
| | Certified | 1st. Recycling | 2nd. Recycling | 3rd. Recycling |
| Hybrid double cross | 2199 | 1781 | 1430 | 1188 |
| % Yield loss for double cross | | 20 | 37 | 46 |
| Hybrid top cross | 1788 | 1504 | 1489 | 1211 |
| % Yield loss for top cross | | 16 | 17 | 32 |

How profitable is recycling HMVs?

The yield losses have economic implications to the producer, buyer, consumer and the whole economy at large in terms of food provision and lost revenue. Farmers, who recycle hybrid maize seed, therefore save on cost of purchasing seed. This gives positive net benefits for the recycled. Though there are positive net benefits from recycling HMVs (Table 5), there is loss of revenue at an increasing rate. This could be why most farmers do not recycle beyond the third generation levels. Thus it is not economical to recycle seed.

Tables 5. A partial budget analysis of recycled verses fresh high yielding hybrid maize.

(Exchange rate 1 US\$=KSh. 75.00)

| Variety name/kind | Profitability indicator by generation level | | | |
|------------------------|---|----------------|----------------|----------------|
| | Certified | 1st. Recycling | 2nd. Recycling | 3rd. Recycling |
| Double crosses | | | | |
| Total Revenue (KSh)/ha | 60328.75 | 47706.75 | 37354.25 | 31536.75 |
| Total cost (KSh)/ha | 29774 | 24803.5 | 23117.75 | 23117.5 |
| Net benefits (KSh)/ha | 30554.75 | 22903.25 | 14236.5 | 8419.25 |
| Top crosses | | | | |
| Total Revenue(KSh)/ha | 58095 | 48879 | 48391 | 39370.5 |
| Total cost (KSh)/ha | 29774 | 24803.5 | 23117.75 | 23117.5 |
| Net benefits (KSh)/ha | 28321.25 | 24075.5 | 25273.25 | 16253 |

Source: On-farm trials 2002-2004

Determinants of recycling hybrid maize varieties

According to the logit results indicated in Table 6, the amount of fertilizers negatively influences the household head to recycle HMs. The higher the amount of fertilizer to be applied the less the likelihood of recycling. Higher fertilizer application requires more cash and most farmers who recycle are cash constrained and cannot afford or willing to invest in fertilizers. The amount of labour hours for the family and hired labour positively and significantly influence the farmer to recycle. Thus, the higher the family labours the higher the likelihood of recycling. Wealth status of individuals negatively and significantly influences the recycling. The higher the wealth status the less likely the farmers will recycle the seed. Wealthy farmers have the ability to purchase fresh seed. In addition amount of credit positively and significantly influences the farmers to recycle. The higher the credit received the less likely the farmer will recycle. Credit could be in terms of cash or kind (eg fertilizers) so farmers who get more credit are likely not to recycle the seed. Contact with

extension service negatively influences the likelihood of recycling. Access to extension services provides greater access to information concerning hybrid vigour, so they are likely not to recycle. Education level of HHH negatively influences farmers not to recycle. However, the coefficient is not significant. Also Pesticides and herbicides are high input options for the farmer so if the farmer cannot afford to buy seed it is expected that he is unlikely to apply the inputs. However the coefficients were not significant.

Table 6. Logit model factors influencing adoption of Recycled maize in Kenya

| Variable | Coefficients | SE. | t-value |
|---|--------------|--------|---------|
| Quantity of seed per ha. | 0.0003 | 0.0018 | 0.1700 |
| Quantity of herbicide per ha. | 0.0049 | 0.0042 | 1.1600 |
| Quantity of insecticide per ha. | -0.0008 | 0.0009 | -0.9600 |
| Quantity of fertilizer per ha. | -0.0018*** | 0.0006 | -3.0100 |
| Quantity of labour per ha. | 0.0002** | 0.0001 | 2.8200 |
| Amount of maize sold in kg per household | -0.0000 | 0.0000 | -0.1000 |
| Extension contact | -0.2344* | 0.1341 | 1.7500 |
| Wealth per household (number of cattle) | -0.3931*** | 0.1247 | -3.1500 |
| Age of household head in years | 0.0019 | 0.0044 | 0.4300 |
| Education of household head (years) | -0.0005 | 0.0139 | -0.0400 |
| Gender of household head | 0.2307 | 0.1988 | 1.1600 |
| Amount of credit per Household per year (KSh) | -0.4337*** | 0.1375 | -3.1500 |

| | | | |
|----------|--------|--------|--------|
| Constant | 0.3112 | 0.3591 | 0.8700 |
|----------|--------|--------|--------|

*Log of likelihood function = 817.9451, Pseudo R-squared=0.576; chi-square=<0.001;

Number of observation=1287.

4.0 CONCLUSION AND POLICY RECOMMENDATIONS

From the results, there is loss in grain yields when recycling maize HMVs. Despite positive net benefits, the loss in yields increases at an increasing rate. This may demand that for incentives to farmers not to recycle HMVs, open-pollinated varieties (OPV) that have recycling option be developed. These incentives can be in terms of favorable input–output pricing strategies. The development of OPV that could have similar characteristics to the most preferred and recycled HMVs may attract farmers to grow and recycle it without significantly losing the grain yield. It is possible that farmers are aware of reduction in yields when they recycle the seed but the ability to invest in fresh seed is curtailed by socio-economic constraints like the pricing along with other high input production technological components.

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