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A decision framework for resource poor smallholder farmers on maize production based on results from empirical studies in the coastal lowlands of Kenya

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Maize is a principal food crop in Kenya and the coastal lowlands. Choice of the enterprise at household level is influenced by the social position maize commands both as a staple food and trade facility or good while production patterns are dictated by various factors among them being resource endowment. Research in the recent past has provided technological recommendations that include fertilizer and pesticides use along with yield data with different management regimes. In the event of not using fertilizer or pesticides, yield losses of 0.421 and 0.203 by proportion of the yield potential were recorded in two different empirical studies respectively for the improved varieties thereby translating to a total gross margin short-fall of KES. 11,192/= per hectare. The household economic effect of this loss therefore doubles to wastage of land space and on the overall denied economic returns to labor devoted to the enterprise. The findings give evidence to recommend devotion to hard decisions on enterprise choice in place of maize especially where land is a limiting factor. High value short duration crops or a balanced cropping mix are thus recommended as best bet alternatives.

Key words: Maize, yield losses, field pests, fertilizer, coastal lowland, gross margin, resource poor and household.

INTRODUCTION

Maize (*Zea mays*) is an important staple food crop for most households in Kenya and the main source of income and employment for the majority of rural households (Kirimi et al., 2011). Food security and welfare of farming population are dependent on the productive capacity of the maize farmers (Liverpool-Tasie et al., 2011). More than 70% of the maize area in Kenya is cultivated by small holders whose maize acreage is below 20 acres (Karanja, 1990). Maize is also the most important food crop at the coast particularly in Kwale

(Kega et al., 1994) and in Kilifi (Otieno et al., 1994) of the coastal Kenya region which account for half of all maize produced in the region. As the main staple food crop, maize is grown across all the agro-ecological zones in the region even where land is suitable for livestock and millets (Wekesa et al., 2003).

Maize yield potential is influenced by rainfall regime and soil nutrient levels. The coastal lowlands are known to be comprised of diverse ecological potential ranging from the coastal lowland (CL) 2 to 6 within which rainfall

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regimes and significantly varying soil types and nutrient levels (Wekesa et al., 2003). Maize is grown across all these CLs hence this ecological spatial stretch justifies the social and economic significance of the enterprise to the farm households and its overall implication if there is total failure due to any eventualities. Other ecological challenges that influence maize performance include management regimes based on moisture and nutrient availability as well as prevention of field losses emerging from pests and diseases (Morris et al., 1999). Efforts to address water stress, nutrient needs, pest and disease resistance in maize have been done through collaborative work between the Kenya Agricultural Research Institute (KARI) and the Maize and Wheat Improvement Centre (CIMMYT) through the Insect Resistant Maize for Africa (IRMA), Nitrogen Use Efficiency (NUE), Water Efficient Maize for Africa (WEMA) and the Drought Tolerant Maize for Africa (DTMA) programs and some progress has been attained. Different studies have also been conducted on response of maize to different management regimes such as those for fertilizer (with or without) by Muli et al. (1998) and yield performances. A number of farm households still prefer local maize varieties for diverse reasons including taste superiority and the long experience they have in growing these varieties (Odeno et al., 2001). Even with the preference for the local maize cultivars, De Groote et al. (2005) observed an increasing adoption in improved maize seed which as a result improved per unit area grain yield under recommended management regimes. For the potential of all maize varieties to be realized, optimal application of inputs such as fertilizer and pesticides is a necessity which requires the farm households' purchasing power. Pender, (2008) linked the inability to access among other factors basic agricultural inputs to poverty.

In the coastal lowland Kenya, unavailability of the improved seed due to poor spatial spread of agro-dealers also complements use of local seed. Further and more critical, the coastal small holder farm households live in a resource poor framework which limits them to access important inputs such as improved seed, fertilizer and pesticides (Wekesa et al., 2003). It is therefore from the recognition of the farm households' resource framework (including land parcel or size holding) that an economic evaluation of the maize enterprise returns was done after accounting for all the eminent losses (from lack of fertilizer and pesticides use) in order to provide a decision framework on the best bet alternatives to the maize enterprise.

LITERATURE REVIEW AND ECONOMETRIC FRAMEWORK

This study was borne from advances made from on-farm work involving small holder maize farmers in maize production under different management resource regimes

that included fertilizer use and protection from field pests. An econometric framework was then generated where maize yield potentials were used alongside and input management regimes (use or no use) as sources of variation on yields (variance components comparison). The suggested model can then be used to estimate expected yield gaps or economic losses that small holder farmers need to accommodate in the absence of applying recommendations. De Groote (2005) estimated yield losses from the stem borers (field pests) using an iterative approach where he estimated yield loss as difference between potential (Y_p) and actual yield (Y_r) and then expressing the difference as a proportion of potential yield, hence;

$$r = \frac{Y_p - Y_r}{Y_p} \quad (1)$$

This loss follows lack of control of field pests and similarly, it is also possible to estimate the yield loss in the event of not using fertilizer as:

$$n = \frac{Y_p - Y_n}{Y_n} \quad (2)$$

Where Y_n is the actual yield when no fertilizer is used and n is the proportion of yield lost when no fertilizer is used.

Under normal farm conditions, the effects of not using fertilizer nor controlling field pests occur concurrently and is therefore postulated that the economic loss is a summation of the two and can therefore be summarized as (Plessis, 2003):

$$Y_{tl} = \frac{\Sigma(Y_p - Y_r, Y_p - Y_n)}{Y_n \quad Y_p} \quad (3)$$

Where Y_{tl} is the overall proportion of yield loss from not field pests and not using recommended fertilizer which can be expressed as:

$$Y_{tl} = \Sigma(r, n) \quad (4)$$

$$Y_{tl} = r + n \quad (5)$$

Hence for the decision framework to be functional, two empirical studies by Hugo De Groote (2005) and Muli et al. (1998) were used alongside current maize farm-gate market price (P) (2013/2014) of KES. 30/= per kg. This therefore implies that the farm household economic loss (E_l) expressed as a proportion of the potential yield will be;

$$E_l = P * (r + n) \quad (6)$$

Table 1. Extent of grain losses (in metric tons) from field pests per hectare by agro-ecological zone in Kenya

Agro-ecological zone	Grain yield/loss parameter				
	Yield (t/ha)	Production '000 tons	Loss '000 tons	% loss of potential	Loss (t/ha)
Lowland tropics	1.29	53	14	20.3	0.346
Dry mid-altitudes	0.98	162	28	14.6	0.175
Dry Transitional	1.15	76	20	20.7	0.315
Moist transitional	2.65	1234	173	12.3	0.386
Highlands	2.88	909	100	9.9	0.320
Moist mid-altitude	1.34	231	60	20.7	0.374

Adapted from De Groote (2005).

Table 2. Results from an empirical study of maize under fertilized and unfertilized conditions.

Treatment/parameter	Variety actual/realized yields (in t/ha)			
	PH4	PH1	CCM	Local
Fertilized	4.2	3.2	3.2	2.8
Unfertilized	2.3	2.0	1.8	1.6
Yield gap/loss	1.9	1.2	1.4	1.2
Proportion of loss to yield under fertilized condition	0.452	0.375	0.438	0.429

Adapted from Muli et al. (1998).

and the money value of the salvaged yield will be;

$$S_{yv} = 1 - P^*(r + n) \quad (7)$$

for S_{yv} =value of salvaged yield.

MATERIALS AND METHODS

The study is based on on-farm work done in the coastal lowlands in Kwale and Kilifi Counties (Makambani, Mtepeni and Goshi) by De Groote, (2005) and Muli et al. (2008) in separate studies for assessing and estimating maize yield losses from field pests and no fertilizer use respectively but using the same maize variety based incomplete block design where ten farms were used in each of the three clusters (Makambani, Mtepeni and Goshi) and four maize varieties namely Pwani 1 (PH1), Pwani 4 (PH4), Coast Composite Maize (CCM) and local were evaluated.

The three sites are all located within the coastal lowland tropics and represented an average agro-ecological potential ranging from the coastal lowland zone three (CL3) through to CL4/5 and a soil type variation characteristic of the coastal lowland tropics as described by Hassan (1998). For the purpose of this study and with the increasing adoption of improved maize varieties (PH1, PH4 and CCM) yield losses results from field pests (De Groote et al., 2005) were used along with the results by Muli et al. (1998) under fertilization and no-fertilization maize production to estimate the total loss as a common option to some households that are either resource constrained or simply do not follow recommendations due to other reasons. The underlying assumption is that the impacts of the farm households' resource framework and underlying decisions are recursive and sequential from plant vigor build-up to yield performance (Schepers and Holland, 2012).

The results on the respective studies on grain loss from field pests and loss from lack of fertilizer use are summarized in Tables

1 and 2. Hence, for the purpose of accounting for the economic impact from field pests and lack of fertilizer use for the maize enterprise of in the region (coastal lowland Kenya), a simple valuation technique using maize grain average market prices stated at Kenya Shillings (KES) 30/= per kg during the year 2010 to 2014 period.

RESULTS

From De Groote (2002) work the proportion of grain loss from field pests (mainly the stem-borer) in the coastal lowland tropics was demonstrated as 0.23 of the potential while Muli et al. (1998) documented a loss proportion from lack of fertilizing maize at 0.421 (on average across all varieties).

This according to the summation model in formula "iii" above adds to a total loss by proportion of 0.624 to the potential yield under controlled conditions (fertilization and field pest control). Further, by using the formula "vi" the economic losses from both scenarios (no fertilizer and no pesticides for field pests) the estimated economic with the application of current grain maize market prices (of KES. 30/= per kg) and using a mean yield potential for the three improved varieties (PH4, PH1 and CCM) of 3.5 tons/ha, the yield loss was estimated at 2.2 tons with a value of KES. 66,000/= per ha.

DISCUSSION

The unchecked losses due to lack of fertilizer use and

control of field pests empirically demonstrated that resource poor households stand to endure heavy economic losses from growing maize. The economic value of salvaged proportion stands at only 37.6% of the potential yield under recommended management thereby implying an economic loss of which losses KES. 39,000/= per ha. This is double loss considering the substitution effect of both land use and labor (Regier et al., 2013) in a dynamic agricultural environment supported by market forces of demand and supply. Using a simple gross margin (GM) analysis (which essentially is the total revenue less variable costs).

Muli et al. (1998) documented a shortfall by proportion of 0.342 per hectare for improved varieties following lack of fertilizer and control of field pests. This short-fall is one which arises from the 0.421 proportion of grain yield from unfertilized maize production system to the potential. Hence by using a similar model which sums the yield losses from unfertilized production system and that where no field pests are controlled (0.203), the total GM short-fall is estimated at about KES. 11,192/= per hectare. The GM short-fall estimation provides an explicit picture of the unattained economic return of the maize enterprise given a scenario where farmers do not practice the agronomic recommendations due to the basal income bracket that groups them in the resource poor platform of farmers (Muli et al., 1998). This paper provides the resource poor farm households with an opportunity at their disposal to choose to grow maize under lack of the recommended package as they prepare to face the aforementioned losses or otherwise.

CONCLUSION AND RECOMMENDATIONS

The estimated aggregate loss proportion emanating from the low input maize production practice (no fertilizer nor pesticide used) clearly demonstrates the economic loss that resource poor farmers undergo or are likely to undergo. The effect of this is a double loss from wasted land due to poor enterprise allocation decisions and wasted labor that in the short or long run is not effectively compensated for (Regier et al., 2013). This paper therefore tries to provide empirical evidence and a decision framework for which farmers and stakeholders in the maize enterprise can use to make hard production decisions despite the position of the maize crop in the farming systems and at household level and the fact that there is a notable out-migration from the high potential to low potential areas due to various reasons including population pressure among other reasons (Karanja and Renkov, 2002).

The paper recommends enhanced efforts to develop early maturing and high yielding maize varieties or a balanced cropping mix particularly to farm households with an average land holding of above one acre and an alternate cropping system for those households with less

than one acre land holding. A second and alternate recommendation is for resource poor farm households to shift to short-duration high value crops whose demand and return value can support inputs' purchase and use. Vegetables such as okra, capsicum, tomatoes, brinjals and spinach are such enterprises recommended for quick and higher returns (Owuor, 2002).

This is a significant shift as that reported by Wachira (2012) on the shift from growing of tree cash crops such as tea and coffee to tomatoes under green house production systems. Wachira (2012) also attributes choice of an enterprise or production system as a consideration of various factors including, costs, returns, and availability of information among others which should be the case with the resource poor famers in the coastal lowlands of Kenya.

Conflict of Interest

The authors have not declared any conflict of interest

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