EVALUATION OF RELEASED MAIZE HYBRIDS TO HASTEN THEIR COMMERCIALIZATION IN COASTAL LOWLAND KENYA

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ABSTRACT
The coastal region of Kenya is a food deficit area with households purchasing one third of their food requirements. Although maize is the most important food crop, the region produces 1.56 million bags, while the demand is 3.80 million bags. This could be attributed to inadequate number of improved hybrids adaptable to the region and also to poor crop management practices including planting patterns. Several high yielding hybrids have been released for the region over the last few years but they have not been commercialized to be accessible to farmers in the region. A study was conducted to evaluate the performance of selected released hybrids under two maize planting patterns (one and two seeds per hill respectively) in a split plot design with planting pattern as the main plots and maize hybrids as the sub-plots. Five maize hybrids (CKH08069, pH4, WE1101, WE2109 and WE2111) were evaluated under the two planting patterns. The results indicated that hybrids WE1101 and CKH08069 had significantly higher ($P<0.05$) grain yield than the other hybrids including the local check (PH4). Hybrid CKH08069 had significantly higher ear height than all the other hybrids including the local check. The same trend was observed for ear length with an exception of the local check. The planting pattern had no significant influence, except for grain yield where the pattern of one plant per hill had significantly higher grain yield than that of two plants per hill.

Keywords: *Maize hybrids, planting patterns, Grain yield, CKH08069, WE1101*

INTRODUCTION
Maize is the main food staple in Kenya, produced by more than 90% of households (Waiyaki et al., 2006). It accounts for more than 20% of agricultural production and 25% of employment in the agricultural sector. More than 70% of maize area is cultivated by smallholder farmers in less than 20 hectares of land (Doss et al., 2003). These small farms produce more than 65% of the maize consumed in the country. Land under maize is about 1.5 million hectares with a total production of 2.34 million tons per year (MoA, 2004). This accounts for 76.5% of the annual consumption estimated at 3.06 million tons.

Maize is the most important food crop on coastal lowland Kenya and is grown in all agro-ecological zones of the region including arid and semi-arid lowland areas more suited for sorghum and millet (KARI, 2005; Wekesa et al., 2003). The region faces a large deficit: while maize is the major staple food, the maize production for its 2.5 million inhabitants (Central Bureau of Statistics, 2001) amounts to only 20 kg/person. The average maize food consumption per person for Kenya is estimated at 94 kg/person (Pingali, 2001). The deficit has to be imported from abroad or other parts of the country. Among the major constraints for maize production in coastal lowlands especially in the semi-arid lands is low soil moisture and lack of improved drought tolerant maize hybrids. Average annual rainfall is low in most areas and total annual evapo-transpiration is high. The evapo-transpiration exceeds rainfall in most months of the year (Jaetzold and Schmidt, 1983). Release of new maize hybrids is constantly taking place in an effort to improve on yields and to widen the choices available for the farmers. However, the region is still constrained by narrow choice of maize hybrids adaptable to the region (Muli, 2000). Coast composite maize (CCM) was released in 1979; Pwani Hybrid I (PH1) in 1989 while Pwani hybrid 4 (PH4) was released in 1995. These hybrids were recommended for the medium to high rainfall zones in the region but due to population pressure people have moved to marginal areas considered best suited for extensive grazing and introduced crop farming. It is also a common practice by farmers to plant two seeds per hill but visual observation has shown that, one of the plants is usually smaller than the other and this is also reflected on cob size.

Several high yielding hybrids with special attributes such as drought tolerance, water use efficiency and maize stalk borer tolerance have been released for the region over the last few years but they have not been commercialized to be accessible to farmers in the region. For the seed companies to commercialize these new hybrids, they need to be provided with information on yield and other special attributes and the advantages over the existing hybrids in the region. There is also need to prioritize the new hybrids to ensure that only the best bet is commercialized to maximize profits by the seed companies. To achieve this objective, a study was conducted to evaluate the performance of selected released hybrids under two maize planting patterns (one and two seeds per hill respectively).

Objectives

1. To prioritize released hybrids for coastal lowland Kenya to enhance their commercialization
2. To determine the effect of planting pattern on yield and yield components of maize hybrids while maintaining the optimum plant population per unit area.
3. To determine the criteria used by farmers in selection of maize hybrids and involve them in the prioritization of the new hybrids for commercialization

MATERIALS AND METHODS

Experimental Site

The study was conducted at Mwabandari in Lungalunga sub-county (Lat. S 04.26.709; Long. E 039 18.540), Kwale county in 2014 and 2015. The study area is described as a coconut - cassava zone in Agro-Ecological Zone (AEZ) Coastal Lowland (CL) 3 (Jaetzold and Schmidt, 1983). The altitude of the area is 142 m above sea level. The site has loamy with a pH of 6.5. The mean annual rainfall for the site is 1100 mm distributed between two seasons of April to August and October to December. The mean monthly minimum and maximum temperatures are about 21 and 28°C, respectively.

Newly released drought tolerant and water use efficient maize hybrids: WE1101, WE2109, WE2111 and CKH08069 alongside a commercial check (PH4) were used in this study. The five hybrids were evaluated under two planting patterns of one and two seeds per hill but maintaining the same plant population of 53,333 plants per hectare. The inter-row spacing was 75 cm and within row spacing was 25 cm for one plant per hill and 50 cm for two plants per hill. The treatments were laid out in a split plot design with planting patterns assigned to main plots and maize hybrids assigned to sub-plots. The treatments were replicated three times. Plots consisted of six rows of maize and the net lots comprised of four rows. Both phosphate and nitrogenous fertilizers were applied at the rate of 46 t ha^{-1} P_2O_5 and 60 t ha^{-1} respectively. Phosphate fertilizer was applied at planting alongside the first split of 18 t ha^{-1} Nitrogen. Additional nitrogen fertilizer was applied as top-dress at a rate of 42 t ha^{-1} four weeks after planting. To control maize stalk-borer, *bulldock* (0.05 GR 0.5g/kg beta cyfluthrin) was applied at the rate of 8 kg ha^{-1} three weeks after planting.

Twenty two farmers were invited to evaluate the maize hybrids at both vegetative stage and at harvest on a cross-sectional basis (without differentiating the evaluating panel on gender, age, and other socio-economic variables). The farmers developed the evaluation criteria through consensus and used the same to evaluate the maize hybrids. The criteria at vegetative stage were given as: Ear size, maturity period, ear height and husk cover. At harvest the criteria were as follows: Cob size, cob filling, ear rot and grain texture (grain recovering after pounding the maize). Maize varietal evaluation was then conducted by pair wise comparison of hybrids and both frequencies and mode determined.

Data were collected on: stand count, plant height, ear height, ear weight, and grain weight and grain moisture content. Stand count entailed counting all the plants in each plot excluding the end plants. Both plant and ear height were measured using a metre rule and recorded in centimetres. The harvested maize was shelled, grain weighed and moisture content measured using a moisture meter.
Agronomic data were subjected to analysis of variance using the linear model:

$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \gamma_k + (\alpha\gamma)_{ik} + \varepsilon_{ijk}$; Where:

$i = 1,...,a$ indexes the main plot levels
$j = 1,...,b$ indexes the blocks (replications)
$k = 1,...,r$ indexes the subplot levels

The variance associated with $(\alpha\beta)_{ij}$ (Error 1) is used to test the main plot effects.
The variance associated with ε_{ijk} (Error 2) is used to test the subplot and interaction effects

RESULTS AND DISCUSSION

Analysis of variance results for the five maize hybrids under the planting patterns is summarized in Table I. The data presented is for the combined two subsequent long rainy seasons of the study period. There was no significant interaction between the hybrid and the planting patterns and therefore the main effects of the two factors are presented separately.

Table I: Analysis of variance results for the five maize hybrids under the two planting patterns

SOURCE	DF	Type 111 SS	Mean Square	F Value	Pr > F
REP	2	6.52200000	3.26100000	9.95	0.0068
PP	1	5.46133333	5.46133333	16.67	0.0035
ERROR 1	2	0.26866667	0.13433333	0.41	0.6769
HYBRID	4	10.37800000	2.59450000	7.92	0.0069
PP*HYBRID	4	3.14866667	0.78716667	2.40	0.1356
ERROR 2	8	2.10800000	0.26350000	0.80	0.6173

All the hybrids were similar in terms of plant height, however, significant ($P<0.05$) differences were observed among the hybrids in terms of ear height (Table II). Hybrid CKH08069 showed significantly ($P<0.05$) higher ear height than all the other hybrids including the check. Hybrids WE2109 and WE2111 revealed significantly ($P<0.05$) lower ear placement than the check (Table II). Ear height is an important factor since it has a bearing on stem lodging and also damage by domestic animals. Plants with very high ear height and prone to stem lodging and plants with very short ear height are liable to damage animals including dogs and chicken. Ear length was similar among the hybrids but significant ($P<0.05$) differences were observed between CKH08069 and both WE2109 and WE2111. The same trend was observed for a 1000 kernel weight with an exception of WE1101 which showed significantly ($P<0.05$) higher at 1000 kernel weight than the rest of the hybrids including the check. The 1,000 kernel (1,000 K) weight is a measure of seed size. It is the weight in grams of 1,000 seeds. Seed size and the 1,000 K weight can vary between varieties of the same crop and even from year to year. By using the 1,000 K weight, one can account for seed size variations when calculating seeding rates acreage.

Both ear length and 1000 kernel weight play a big role in determining the final grain yield. Inamula et al. (2011) and Rafique et al. (2004) reported positive correlation ($P<0.05$) of ear length with 1000 kernel weight and grain yield. Grain yield for the hybrids ranged from 5.22 to 6.8 t ha^{-1} for WE2111 and WE1101 respectively (Table II). Generally, the yields were high compared to the expected yield for existing commercial hybrids and this was attributed to high yield potential of some of the test hybrids and favourable weather conditions during the cropping season, especially in 2015. Hybrids, WE1101 and CKH08069 had significantly ($P<0.05$) higher grain yield than the other test hybrids and the local check. However, hybrid WE2111 showed significantly ($P<0.05$) lower grain yield than the check. There were no significant ($P<0.05$) yield differences between WE2109 and the check (Table II).

Table II: Mean effect of maize hybrid parameters for the two seasons

Maize hybrid	Plant height (cm)	Ear height (cm)	Ear length (cm)	1000 K WT (g)	Grain yield (t ha^{-1})
WE2109	221.9	95.7^{c}	16.0^{b}	281.0^{b}	5.96^{b}
WE2111	216.7	92.1^{c}	16.6^{b}	278.7^{b}	5.22^{c}
PH4	215.6	107.0^{b}	17.3^{ab}	288.5^{b}	5.75^{b}
WE1101	215.2	101.6^{b}	17.2^{ab}	331.2^{a}	6.80^{a}
CKHO8069	209.6	112.8^{a}	17.9^{a}	297.9^{b}	6.67^{a}
CV	**2.8**	**9.8**	**3.7**	**3.1**	**9.4**
LSD	**17.66**	**5.58**	**1.32**	**27.55**	**0.68**

Means followed by the same letter are not different ($P\leq0.05$) within the same column

The pattern of planting had a significant ($P<0.05$) influence on plant height, ear length and grain yield but not ear height and a 1000 kernel weight (Table III). The treatment of one seed per hill showed significantly taller plants than the treatment of two seeds per hill. This result also confirmed the visual observation that when two seeds are planted per hill, one of the plants is always smaller than the other and this observation is also reflected in ear size. This is attributed to intra-plant completion for soil resources. As visually observed, the treatment of one plant per hill revealed significantly ($P<0.05$) higher ear length than that of two seeds per hill. Though not significant, the one seed per hill treatment had higher at 1000 kernel weight than that of two seeds per hill. The results also show that significantly ($P<0.05$) higher grain yield was obtained for the treatment of one plant per hill that that of two seeds per hill. This was expected because ear length and a 1000kernel weight are important components of final grain yield

Table III: Mean effect of planting pattern on plant parameters for the two seasons

Planting Pattern	Plant height (cm)	Ear height (cm)	Ear length (cm)	1000 K WT (g)	Grain yield (t ha^{-1})
One seed/hill	220.8^{a}	105.5^{a}	17.7^{a}	301.6^{a}	6.51^{a}
Two seeds/hill	210.8^{b}	98.2^{a}	16.3^{b}	289.3^{a}	5.65^{b}
CV	**2.8**	**9.8**	**3.7**	**3.1**	**9.4**
LSD	**8.04**	**13.71**	**0.61**	**16.36**	**0.58**

Means within the same column followed by the same superscript are not different ($P\leq0.05$)

Farmer evaluation of the hybrids at vegetative stage and at harvest

From farmer evaluation, hybrids were selected and ranked based on attributes discussed herein. Farmers ranked hybrid CKH08069 as number one because it scored highly in nearly all the attributes especially ear size, early maturity and ear height (Table IV). They also justified their selections/scores as follows: Ear size is an indicator of yield and early maturity guarantees early access of food during the season. The results agree with Zaire et al. (2012) who documented positive correlations of cob length and yield among maize hybrids in Iran. The farmers also said that ear height is an important attribute as a means of protection against damage by domestic animals such as dogs and chicken

Table IV: Maize hybrid pair-wise ranking by farmers at vegetative stage

Hybrid	Ear size	Early maturity	Ear height	Husk cover	Overall	Rank
WE2109	3.8	4.1	3.7	4.1	3.9	**2**
CKH08069	4.3	4.1	4.0	3.9	4.1	**1**
WE2111	3.6	3.4	3.8	3.6	3.6	**5**
PH4	3.7	3.8	3.9	3.3	3.7	**4**
WE1101	4.0	3.7	3.8	3.5	3.8	**3**

At harvest, hybrid WE1101 scored highly in all the attributes used as criteria by the farmers. A very high score was given for ear size and grain texture (Table V). The results demonstrate transitivity and preference for cob size as having linear relationship with grain yield as observed by Rage wetter, et al. (2011). Grain texture has a bearing on grain recovery when maize is pounded which is common practice by farmers in the study site. Both CKH08069 and WE1101 are suitable hybrid that can improve food availability between harvests since cob size is a good indicator of harvest quantity.

Table V: Maize hybrid pair-wise ranking by farmers at harvest

Hybrid	Ear size	Grain filling	Ear rot	Grain texture	Overall	Rank
WE2109	3.5	3.4	3.5	3.2	3.4	**5**
CKH08069	4.5	4.3	4.1	3.1	4.0	**2**
WE2111	3.6	3.4	3.8	3.6	3.6	**4**
PH4	4.1	3.8	4.1	3.2	3.8	**3**
WE1101	4.6	4.1	4.4	4.5	4.4	**1**

CONCLUSION

CKH08069 is suitable candidate for any seed company to commercialize because of its high yield and preference by farmers. Planting pattern plays a role in determining the final yield and farmers should be encouraged to plant one seed per hill. It is important to involve farmers in varietal development since they provide an insight on their preferences for any particular variety.

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