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Full Length Research Paper

Fertilizer options for sustainable maize *(Zea mays L.)* production in the Trans- Nzoia district of Kenya

Owino Charles Onyango

Kenya Plant Health Inspectorate Service. P.O. Box 249, Kitale, Kenya. E-mail: onyangochrls@yahoo.com. Tel: 0721794367.

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With increasing human population against declining staple food crop yield trend, food insecurity is inevitable. Soil fertility problem has been identified as a major factor hindering maize productivity in Trans Nzoia district. Majority of these soils are acidic, deficient in nitrogen, phosphorus and at times other nutrient elements. A factorial experiment was laid out in randomised complete block design, with fertilizer option being main plot and variety as sub plot to explore better fertilizer treatments for maize production in Trans Nzoia. The treatments included three maize varieties and five fertilizer options. The maize varieties used were H.614D, H.6213, H.9401, while the fertilizer options included control (no fertilizer), farmyard manure (FYM) (one handful per hole), single super phosphate-SSP (188 kg/ha), diammonium phosphate-DAP (188 kg/ha) and DAP 125 kg/ha). There were significant yield differences among fertilizer treatments and among the varieties. DAP at 188 kg/ha and H.6213 gave the best mean yields of 10.19 and 9.62 kg a plot, respectively. SSP at 188 kg/ha and H 614 D treatments resulted in dismal crop yield performance of 8.03 and 8.46 kg a plot, respectively. Up to 23% yield can be lost in the field as rots especially with maize varieties exhibiting open cob tips.

Key words: Trans-Nzoia district, maize, variety, yield, diammonium phosphate, farmyard manure, single super phosphate.

INTRODUCTION

Maize is a staple food crop in Kenya (Groote, 2002; Khan et al., 2001; Owino, 2009), forming a major component of diet of majority of Kenyans' meals in forms of *ugali githeri* and porridge and indirectly as feed for animal products. It is grown as a subsistence and/or commercial crop across the country with the largest production being in the Trans Nzoia district (Owino, 2009; Onyango, et al*.,* 2000), Nyamangara et al. (2003) reported that smallholder cropping in much of southern and eastern Africa is based on maize, the staple food crop.

Unfortunately, the yield trend has been declining over the past years (Onyango et al*.,* 2000). Several reasons including continuous cropping, increased population pressure on arable land, degradation of land as natural resource, low investment in soil fertility, inappropriate production technologies, and episodes of bad weather have been cited for this phenomenon (Groote, 2002; Kamidi et al., 2000; Mwangi et al., 2001; Kedera et al., 1999).

With increasing human population against declining staple food crop yield trend, food insecurity is inevitable. Many Kenyans face starvation in several rural areas at some time every year causing loss of lives and untold misery among legitimate citizens. This contradicts the government's policy on poverty reduction strategy since promotion and attainment of food security is recognised as the initial step towards poverty alleviation and rural development. Factors that constrain food production (maize included) must be addressed to change this scenario.

Soil fertility problem has been identified as a major factor hindering maize production in the Trans Nzoia district (Onyango et al*.,* 2000; Mwangi et al., 1997). Majority of these soils are acidic, deficient in nitrogen, phosphorus (Onyango et al*.,* 2000) and at times other nutrient elements. Over time, farmers in the district have used diammonium phosphate (DAP) to augment the nutrient deficits since this fertilizer source supplies the two most frequently limiting nutrient elements (Nitrogen and Phosphorus) in one application. Unfortunately, DAP is known to increase soil acidity by releasing a proton

(H^+) during the nitrification process of the ammonium ion. This compounds the problem since phosphate absorption is increased under low pH soil reaction. The continual use of DAP is blamed for the declining crop yields in the district. On the other hand majority of resource poor farmers do not use inorganic fertilizers while those who use often apply less than recommended fertilizer rates. It is against this background that an experiment was conducted to explore the various maize varieties and fertilizer options that would improve maize production without undue soil acidification, thereby restoring the district to its true glory as Kenya's 'grain granary', hence creating food security and reducing poverty in the country.

MATERIALS AND METHODS

The experiment was conducted in three consecutive years from 2004 to 2006 at KEPHIS-Kitale regional office, in Trans Nzoia district. The site lies between latitude 01° 01'N and longitude 035° 00E, at an elevation of 1875 m above sea level (a.s.l) with mean monthly rainfall amounts of 104 mm. The pH, total nitrogen, available Phosphorus and Potassium values of the site were 5.1, 0.17%, 8.1 ppm and 0.09 m.e%, respectively. The treatments included three maize varieties and five fertilizer options. The maize varieties used were H 614D, H 6213 and H 9401. These are late maturing high yielding maize varieties commonly grown by farmers in the district. The fertilizer options were control (no fertilizer), cow dung farmyard manure (FYM) (5 ton/ha), single super phosphate (SSP) (188 kg/ha), DAP (188 kg/ha) and DAP (125 kg/ha). Most farmers in Trans Nzoia use either DAP or SSP as planting fertilizer at various application rates while some of the small scale holders use FYM. This was a factorial experiment laid out in randomised complete block design, with fertilizer option being main plot and varieties as sub plot, giving 15 treatments. To reduce block length so as to maximize block homogeneity, the block was folded five times. The treatments were replicated three times each year. Each plot measured 5 x 3.75 m. A 0.75 m (inter row) and 0.25 m (intra row) spacing was used. Planting was done at the onset of long rains every year in April. Two seeds were planted per hill and fourteen days after germination thinned to one plant per hill. Top dressing was uniform across the treatments at a rate of 188 kg of calcium ammonium nitrate (CAN) per ha when the crop was approximately 0.9m high. All other agronomic practices were uniformly applied as and when necessary.

A sample unit was a complete treatment plot. At physiologic maturity, plots were harvested separately. The economic yield was apportioned into clean and rotten cobs. The yield was shelled, dried to 13.0% kernel moisture content and weighed. The data was statistically analysed using SAS computer package (SAS, 1998).

RESULTS AND DISCUSSION

There were significant yield differences among fertilizer treatments and among the varieties (Table 1 and Figure 1). However, there was no significant effect on yield due to interactions.

Fertilizer treatment effect

DAP at 188 kg/ha resulted in the best mean yield across the varieties while SSP was the worst treatment (Figure 2). However, there was no significant yield difference among DAP at 188 kg/ha, DAP at 125 kg/ha and farmyard manure (Table 2). The dismal performance of SSP is attributed to the fact that this fertilizer source lacks N, an integral plant nutrient requirement. As such, the crop was stressed at initial stages of growth, showing chlorosis symptoms before top dressing. This retarded growth resulted in poor yield. Moreover, P fixation couldhave occurred given the acidic soil reaction.

The non-significant difference in yield between SSP and control (nil fertilizer) was because the applied P was readily fixed since the soil was acidic (Fardeau and Zapata, 2002; Othieno, 1973; Midgley, 1941). Moreover, application of P alone without N may have resulted in poor P uptake since the two elements are known to be synergistic in uptake of one other (Sangakhara and Cho, 2008).

Varieties treatment differences

While H 6213 was the best performer, H 614D was the worst among the three varieties (Figure 3). However, there was no significant difference in yield between H 9401 and H 614D (Table 3), the two being highland varieties with equal yield potential

Data for 2006 showed that up to 23% of the yield can be lost in the field as rotten cobs (Figure 4). This partly explains the disparity between farmers' yield and the potential yield documented by breeders. H 614D and H 9401 had high % rotten cobs than H 6213. The high rotting incidences in H 614D and H 9401 are attributed to lodging susceptibility and open tips observed in these varieties, respectively.

Despite the relatively low yield and high % rot in H 614D, most farmers still adore this old variety probably due to their being ignorant about existence of new improved varieties and partly due to the variety's hardy nature, high kernel test weight and good storability.

CONCLUSIONS AND RECOMMENDATIONS

For the country to maximise the benefit from breeders' work, concerted efforts is needed to convince the farming fraternity to use new improved maize varieties coupled with feasible and ecologically sustainable soil fertility replenishment technologies. Adequate and prudent use of inorganic fertilizers combined with new improved maize varieties in Trans Nzoia district can change the downward maize yield trend. Small holder farmers who practise mixed farming should not despair either since organic manure is equally good and can save them the high cost and uncertain accessibility of inorganic fertilizers. Other than slow nutrient release, organic sources also increase the soil carbon content, thereby improving soil biophysical condition, nutrient recovery and residual effects. Though DAP gave encouraging

Table 1. Analysis of variance (ANOVA).

Source	df	ss	mss	F value	P>F
Year	1	0.47702496	0.47702496	0.20	0.6595ns
Rep (year)	4	1.38830624	0.34707656	0.14	0.9656[ns]
Fertilizer	4	68.63480615	17.15870154	7.05	0.0001**
Rep × Fertilizer	8	27.54270972	3.44283872	1.42	0.2085ns
Variety	2	19.15200159	9.57600079	3.94	0.0247*
Fertilizer × Variety	8	9.55675289	1.194559411	0.49	0.8580[ns]

ns, not significant; ** significant at 1% (highly significant); * significant at 5%; cv = 17.4%.

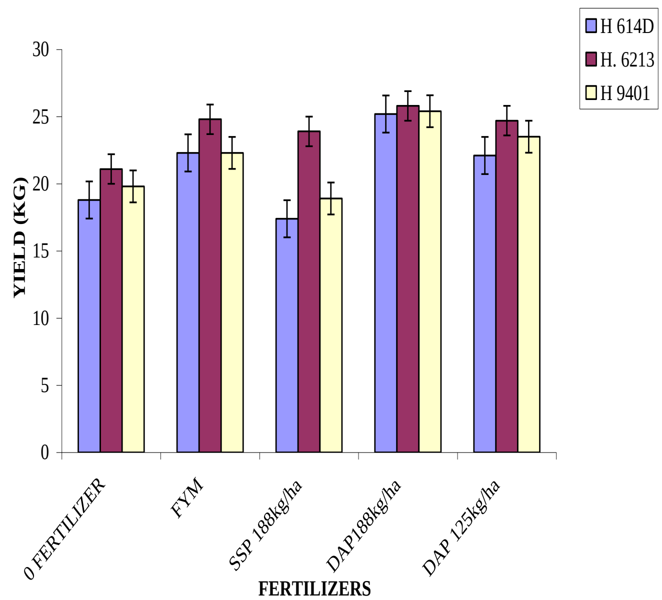

Figure 1. Differences in yield among fertilizers and varieties.

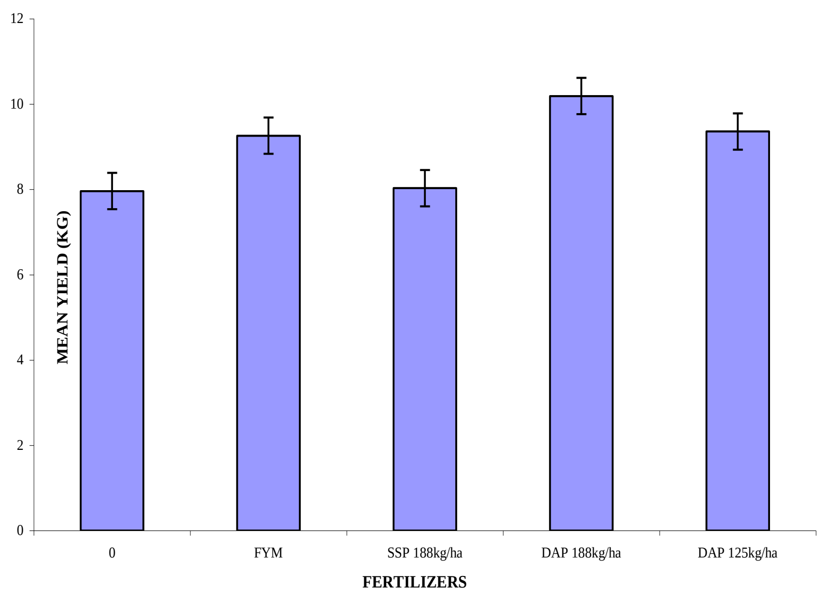

Figure 2. Mean fertilizer effect.

Table 2. Probabilities of fertilizer treatment mean yield differences.

		Probabilities				
Fertilizer	**Yield**	**DAP 188**	**DAP 125**	**FYM**	**SSP 188**	**0 (nil) fertilizer**
DAP 188	10.19[a]	.	0.1118	0.0754	0.0001	0.0001
DAP 125	9.36[a]		.	0.8461	0.0137	0.0080
FYM	9.26[a]			.	0.0221	0.0133
SSP 188	8.03[b]				.	0.8798
0(NIL) fertilizer	7.96[b]					.

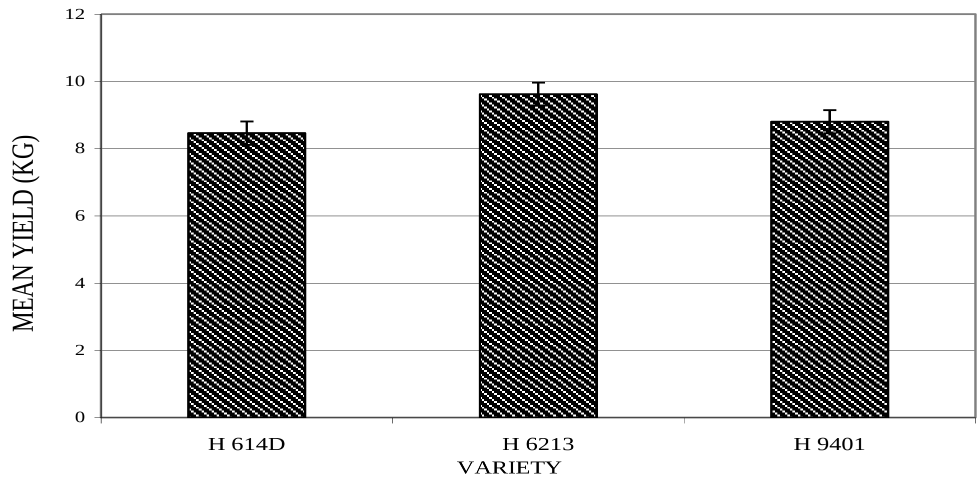

Figure 3. Variety mean yield.

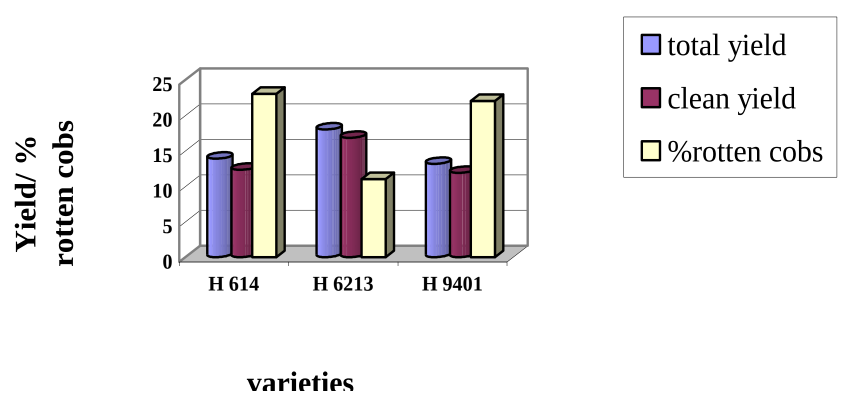

Figure 4. Variety mean yield (kg) and % rot-2006.

Table 3. Probabilities of varieties mean yield differences.

		Probabilities		
Variety	**Yield**	H 6213	H 9401	H 614D
H 6213	9.62[a]	.	0.0446	0.0055
H 9401	8.80[b]		.	0.4048
H 614D	8.46[b]			.

results, use of other non-acidifying fertilizers should be advocated since persistent use of DAP is a time bomb that will adversely affect soil condition and ultimately yields. Practices that ameliorate soil acidity should be encouraged in this region. Use of the expensive complete fertilizers should be tried out. The option of using a mixture of CAN and SSP at planting should be explored too. This experiment needs to be replicated in several other sites both within and beyond the district. The treatments also need to be broadened so as to be as inclusive as possible.

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