MAIZE SINGLE CROSS HYBRID FOR TOLERANCE TO LOW PHOSPHORUS IN ACID SOILS OF WESTERN KENYA

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ABSTRACT

Maize (Zea mays L.) is one of the world’s most important staple food crop. Its production is however, limited by phosphorus (P) deficiency in acid soils. The objective of this study was to develop single cross hybrids from P-efficient inbred lines and screen them for tolerance to P deficiency in the acid soils at Segal and Bumula in western Kenya. Forty nine single cross hybrids were developed and screened for tolerance to low (P=2.2 mgP/kg) soil P under field conditions. Mean grain yield for the hybrids was 5.9tha under P compared with only 3.6tha without P. Plant and ear weights were reduced by about 14.8%. Thirty three per cent of these crosses were inefficient but responsive to P application, 27% were efficient and none responsive and only 2% were efficient and responsive. Grain yield was positively correlated (r = 0.57**) with plant height and ear height (r = 0.60**) and plant height with ear height (r = 0.86**). However, grain yield had low and negative correlation with days to 10% tasseling (r = -0.32) and days to 50% tasseling (r = -0.32). This study has developed and identified P-efficient single cross hybrids that can be used either directly or in developing 3-way and/or 4-way cross hybrids for use in acid soils of Western Kenya

INTRODUCTION

Maize (Zea mays L.) is a staple food crop for the majority in developing countries (Lopes and Lakirnis, 1996), although in Kenya maize is grown on acid ferric oxide soils in acid soils (pH 5.5-5.9) characterized by low available P (Kochian et al., 1995). In Kenya, most maize growing takes place in acid soils which occupy about 13.5% of arable land (Kanjyanju et al., 2002 and Mohamud and Underwood, 2004). In acid soils, P is often fixed by Al and Fe oxides leading to its unsaturability. The main plant symptoms (Syers et al., 2000). Kenyan acid soils have very low P (2.5 mgP/kg) and cannot support high P sorption (Obura, 2008; Kisungo, 2011). Phosphorus deficiency leads to a reduction in grain yield of as much as 50% in maize especially on the smallholder farms where agriculturally-based P mining has been occurring for years without replenishment (Gerloff, 1987; Kisungo et al., 2009). In Kenyan acid soils, P deficiency reduces maize yield by about 28% (Ligeayo, 2007). Maize yields in Kenya are generally low (<1.0 t/ha) in small holder farms and have been on the decline over the years (Nekesa et al., 1999; Ayaga, 2003). This is a worrisome trend unless reversed, may lead to major food deficits in future. P-based fertilizers are routinely used in agricultural systems to overcome P deficiency or to supplement P whenever depleted. Continuous application of ammonium based fertilizers lead to more soil acidity (Kochian et al., 2004). Besides, the need to use large doses of P fertilizer to attain reasonable crop yields in acid soils is not affordable to the resource-poor farmers in western Kenya. Genotypic differences for tolerance to P deficiency exist in maize, hence the possibility to select and develop genotypes that are tolerant to P deficiency in acid soils. Although, Brazilian scientists have bred maize varieties with high yields in acid soils (Parentoni et al., 2010), such varieties have not yet been developed in Africa. The purpose of this research was to develop single cross hybrids from P-efficient inbred lines and screen them for tolerance to P deficiency in the acid soils of western Kenya

MATERIALS AND METHODS

The source of inbred lines used to develop the single crosses was Moi University and KARI – Kitale maize breeding programs. Inbred lines were selected by Prof. Samuel Gudu and Dr. Dickson Ligeayo. Some of the inbred lines were derived from Brazilian single crosses that were known to be P efficient by selling up to F3 generations. Others known to be tolerant to maize streak virus (MSV), Grey leaf spot (GLS) diseases and also P-efficient and inefficient, were derived from KARI and Moi University. The single cross hybrids were developed by crossing between P-efficient and inefficient Mupiga inbred lines and between inbred lines developed from Brazilian single crosses. A total of 48 single crosses hybrids and one local check bred for mid altitude (HI05) were planted at Bumula (4.4mg/kg of soil, pH 4.8) and Segal (1.9mgP/kg of soil, pH 4.5). These sites were selected because their soils are characterized by low pH available Phosphorus. The experiment was set up in a split-split plot arrangement in RCBD replicated 3 times. The treatments were low P (0 kg P/ha) and high P (26 kg P/ha) applied as triple super phosphate (TSP). Planting was done at 75 cm 0.3 m 3 long plot. All agronomic practices were carried out. Data was recorded on grain yield (t/ha), Plant height (cm), Ear height (cm), days to 10% tasseling and days to 50% tasseling.

Data analysis

Means of data on yield and yield components were used to compare the performance of the single cross hybrids and the inbred lines in the different environments. ANOVA was computed using Genstat Edition 12 and means separated by Tukey's range test.

RESULTS AND DISCUSSION

Phosphorous treatments were significantly different indicating that P had an effect on the general plant performance under field conditions. No significant interaction was observed between environment and treatment for all the traits except grain yield. There was significant interactions (P ≤0.01) between the genotype and environment for grain yield and plant height while the interactions were not significant for days to 50% tasseling and silking (P ≥0.05). There was significant interactions between the genotype and treatment for grain yield, plant height, ear height and days to 50% tasseling. However, the interaction between genotype and treatment was significant for days to 50% tasseling. On the other hand there were no significant interactions between genotype and environment (Table 1). These results agree with those obtained by Ayaga et al. (2003). However, some of the single crosses at the two sites were associated with high P availability. In control ranged from 1.6-6.6 t/ha but it had increased with the application of P (3.41-8.7). Mean grain yield, plant height and ear height were significantly reduced under additional P with 43% and 21% respectively for all the single crosses. These findings compare well with other studies by Camacho et al. (2002) who showed that low P conditions significantly reduce maize grain yield, plant height and ear height. The findings also compare well with those of Parentoni et al. (2010) who reported a mean grain yield reduction of 47% among Brazilian maize hybrids due to low P

Table 1: Mean square for grain yield and yield components of single cross maize tested for P efficiency across 2 environments

<table>
<thead>
<tr>
<th>Trait</th>
<th>Mean square</th>
<th>df</th>
<th>F</th>
<th>P</th>
<th>LSD at 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain yield (t/ha)</td>
<td>25.32</td>
<td>1</td>
<td>12.2</td>
<td>0.001</td>
<td>5.77</td>
</tr>
<tr>
<td>Plant height (cm)</td>
<td>20.17</td>
<td>1</td>
<td>14.0</td>
<td>0.001</td>
<td>4.67</td>
</tr>
<tr>
<td>Ear height (cm)</td>
<td>16.89</td>
<td>1</td>
<td>12.2</td>
<td>0.001</td>
<td>4.67</td>
</tr>
<tr>
<td>Days to 10% tasseling</td>
<td>13.44</td>
<td>1</td>
<td>9.8</td>
<td>0.004</td>
<td>3.42</td>
</tr>
<tr>
<td>Days to 50% tasseling</td>
<td>11.98</td>
<td>1</td>
<td>8.5</td>
<td>0.006</td>
<td>3.07</td>
</tr>
</tbody>
</table>

CONCLUSIONS AND RECOMMENDATIONS

•Great genetic variability for both P efficiency and responsiveness to additional P exists among maize single crosses.
•This study has identified fourteen single crosses that are P-efficient exceeding a threshold of 4 t/ha under no additional P.
•It is recommended that some of the identified P-efficient lines be used for hybrid production (Double crosses, 3-way crosses and Top crosses).