Full Length Research Paper

Effect of ethephon and planting density on lodged plant percentage and crop yield in maize (Zea mays L.)

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Increasing maize production is vital in many developing countries. One way of increasing production is through adoption of high planting densities. However, high planting densities are associated with intra-specific competition between plants for resources like nutrients, water and sunlight, as a result weak stalks develops which are susceptible to lodging. The challenge of lodging in high planting densities can be reduced by ethephon (2-chloroethylphosphonic acid). A 3 x 2 factorial experiment in randomised complete block design was carried out at New Donnington Farm, Zimbabwe in the 2011/12 rainy season to study the effects of ethephon rates and planting densities on maize. Ethephon rate had the following levels 0 l/ha (control), 0.56 l/ha and 0.84 l/ha while the density consisted of 53,333 and 80,000 plants/ha. Ethephon rate significantly (p<0.05) reduced the plant height of maize as compared to the control plants across different levels of planting densities. Also a significant increase (p<0.05) in internode diameter in the treated stands over the control plants across different levels of planting densities was recorded. Ethephon treatment significantly reduced (p<0.05) the percentage of lodged plants from 6.54 (control) to 4.34 and 2% for medium and high rate, respectively. Grain yield increased significantly in response to increased rates of ethephon at high planting density by 28.5 and 29.1 tons/ha for medium and high rate, respectively.

Key words: Maize, ethephon, planting, density, lodging.

INTRODUCTION

Maize is an important crop in the world and is ranked third after wheat and rice (Hoshang, 2012). In Zimbabwe and other African countries, maize is the staple crop and is grown by majority of smallholder farmers. It is estimated that more than half of the world area under maize production is in developing countries including Africa (Mejia, 2003). In Zimbabwe, despite the extensive area under production of maize in developing countries, the yields are still generally low. The poor yields can be attributed to poor agronomic practices, frequency of drought, biotic stresses among other factors.

Since maize is economically important, increasing its production is vital in African countries. One way of improving production is through adopting high planting densities. High planting densities increase the number of ears per unit area and thereby improving the grain yield (Abuzar et al., 2011). However, too high populations may cause intra-specific competition between plants for resources like nutrients, water and sunlight (Zamir, 2011). In addition, high planting densities are associated with lodging of stalks (Shekoofa and Emam, 2006). Lodging can affect photosynthesis, pollination and yield of maize crop due to poor solar radiation interception.

The challenge of lodging in high planting densities could be reduced by using ethephon (2-chloroethyl-phosphonic acid) (Shekoofa and Emam, 2008). Ethephon
**is an ethylene releasing compound whose effect depends on crop species, amount applied and timing of application (Khuankaew et al., 2009). It is a growth regulator which upon application, increases resistance to lodging through thickening of lower internodes, termination of apical dominance (Shekoofa and Emam, 2006). Besides reducing lodging in crop plants, ethephon has also been found to improve the water use efficiency (WUE) of plants by making water available during critical reproductive growth stages (Campos et al., 2004). Therefore, ethephon can be used to improve crop yield in dry areas which receive very low rainfall (Langan et al., 1987).

Elsewhere, ethephon has been extensively studied as a plant growth regulator used to promote fruit ripening, abscission, flower induction, breaking of apical dominance but there is limited information to show that it has been evaluated as an anti-lodging agent in maize under high planting densities.**

### MATERIALS AND METHODS

A field experiment was conducted at New Donnington Farm in Zimbabwe, which lies between 30°41’ E and 17°52’ S in Norton during the 2011-2012 growing season. The farm is located in Agroecological region 11a about 38 km from Harare along Bulawayo road. The altitude of the area is 1360 m above sea level. The mean annual rainfall is between 950 and 1000 mm per annum whilst the mean annual temperature is 20.6°C. The maximum and minimum temperatures of the area are 26 and 17°C, respectively. The study site was dominated by light, well drained sandy loam soil textures (Nyamapfene, 1991). The design used was a 3 x 2 factorial experiment in randomized complete block design with four replications and the blocking factor was the slope. The first factor was ethephon with three levels, 0, 0.56 and 0.84 l/ha and the second factor was planting density with two levels, 53,333 and 80,000 plants/ha.

Land was conventionally prepared using a tractor drawn disk harrow and a roller to obtain a fine tilth from which seedbeds were raised. A marked wire cable was used to mark planting stations and the seed was hand sown in plots of 4.5 m wide and 5.0 m long. In row spacing was 16.6 (high density) and 25 cm (low density). Inter-row spacing was 75 cm in all plots and uniformity of sowing depth was achieved by using a hand dibbler to make holes of 5 cm deep. A basal fertiliser of Compound D (7% N, 14% P₂O₅, and 7% K₂O) was applied at a rate of 300 and 450 kg per hectare under the low and high planting densities, respectively. Top dressing was done using urea (46% nitrogen), the fertilizer was split applied at the rate of 250 and 375 kg per hectare at the low and high planting densities, respectively at four and eight weeks after planting. The field was kept weed free by the use of Atrazine and Alachlor at 31/ha and 21/ha, respectively. Late and persistent weeds were controlled mechanically by the use of hoes at eight weeks after crop emergence.

Stalk borer (Busceola fusca) was controlled by the use of dipterex (dimethyl 2,2,2-trichloro-1-hydroxyethyl-phosphate) which was applied at four weeks and six weeks after crop emergence at a rate of 4 kg per ha. Ethephon mixed with blood buff (surfactant) was applied in the morning at 8 to 9 leaf stage using a knapsack sprayer. Each plot was surrounded by plastic walls to avoid the drift of the solution to the adjacent plots. Confider was sprayed at physiological maturity to control termites using a knapsack sprayer.

The following measurements were recorded, plant height, internode length and diameter, percentage of lodged plants and grain yield. Data was subjected to analysis of variance using GENSTAT version 14. Number of lodged plants was square root transformed prior to analysis of variance. Treatments means were separated using least significant difference test at 5% level.

### RESULTS AND DISCUSSION

**Ethephon rate and planting density on final plant height and internode length**

There was a significant interaction (p< 0.05) in the final plant height between planting densities and ethephon rates. Ethephon treatment resulted in a significant (p<0.05) reduction of plant height across the two plant densities (Table 1). The reduction in plant height can be attributed to the observed decrease in internode lengths (Figure 1).

**The effect of ethephon on percentage of lodged plants and internode diameter (mm) of maize**

There was significant (p< 0.05) reduction on the percentage of lodged plants following ethephon treatment. The minimum percentage of lodged plants were recorded, plant height, internode length and diameter, percentage of lodged plants and grain yield. Data was subjected to analysis of variance using GENSTAT version 14. Number of lodged plants was square root transformed prior to analysis of variance. Treatments means were separated using least significant difference test at 5% level.

#### Table 1. The interaction between planting density and ethephon rates on final plant height (cm).

<table>
<thead>
<tr>
<th>Ethephon</th>
<th>53,333 plants/ha</th>
<th>80,000 plants/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(low density)</td>
<td>(high density)</td>
</tr>
<tr>
<td>0</td>
<td>277.25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>285.15&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>0.56 l/ha</td>
<td>265.29&lt;sup&gt;c&lt;/sup&gt;</td>
<td>267.6&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>0.84 l/ha</td>
<td>254.15&lt;sup&gt;ef&lt;/sup&gt;</td>
<td>257.55&lt;sup&gt;f&lt;/sup&gt;</td>
</tr>
<tr>
<td>p value</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>Lsd</td>
<td>1.38</td>
<td></td>
</tr>
<tr>
<td>cv (%)</td>
<td>5.3</td>
<td></td>
</tr>
</tbody>
</table>

####Effect of planting density on the percentage of lodged plants

Planting densities had a significant effect (p< 0.05) on...
Figure 1. Effect of ethephon rates on final internode length of maize plant (cm).

Figure 2. Effect of ethephon levels on percentage of lodged plants.

Table 2. The interaction between plant density and ethephon rates on first internode diameter of the maize plant.

<table>
<thead>
<tr>
<th>Ethephon</th>
<th>53,333 plants/ha (low density)</th>
<th>80,000 plants/ha (high density)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 l/ha</td>
<td>28.9070&lt;sup&gt;a&lt;/sup&gt;</td>
<td>28.8555&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>0.56 l/ha</td>
<td>32.4180&lt;sup&gt;c&lt;/sup&gt;</td>
<td>31.2835&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>0.84 l/ha</td>
<td>29.91&lt;sup&gt;e&lt;/sup&gt;</td>
<td>29.7995&lt;sup&gt;f&lt;/sup&gt;</td>
</tr>
<tr>
<td>p. value</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>LSD</td>
<td>0.06025</td>
<td></td>
</tr>
<tr>
<td>CV (%)</td>
<td>5.1</td>
<td></td>
</tr>
</tbody>
</table>
percentage of lodged plants. There was a significant (p<0.05) increase in percentage of lodged plants following an increase in planting densities (Figure 3). This is in agreement with the findings by Liu et al. (2012), who reported that, an increase in planting densities result in risk of root lodging. The intraspecific competition between plants for resources like light, water and nutrients may result in etiolating of the crop thereby weakening the root system and anchoring ability.

**Ethephon and planting density on grain yield (tons per hectare)**

A significant interaction (p< 0.05) between planting densities and ethephon rates was observed for the grain yield (Figure 4). Addition of ethephon resulted in significant differences (p< 0.05) in grain yield between planting densities. Ethephon has been reported to increase maize yield under drought conditions. Since this experiment was set under rain-fed conditions, there are certain times mid dry spells were felt and as such ethephon improved the maize yield. The plant growth regulator increases the grain yield under water stress conditions by extending water availability during critical stages like grain filling (Kasele et al., 1994). The results also showed a significant increase in grain yield under high planting density when ethephon was applied. Ethephon might have reduced lodging in treatments where high planting density was used resulting in more cobs being harvested.
Etherephon had no significant effect ($p < 0.05$) on grain yield under low planting density. The plant growth regulator is not beneficial under low planting densities, as lodging is low as shown in Figure 4.

Conclusions

Etherephon reduces the plant height due to shortening of internodes. The plant growth regulator also reduces the percentage of lodged plants across all plant densities due to increase in internode diameter. Increase in planting densities tends to exacerbate lodging in maize crop. Ethephon increases grain yield under high planting densities and have no effect under low plant population.

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REFERENCES


