Influence of Water Stress and Plant Density on some Characteristics in corn
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ABSTRACT: Maize (Zea mays L.) production under the semi-arid conditions of the Islamic Republic of Iran during the summer requires supplemental irrigation to attain maximum yields. Maize is cultivated in both spring and autumn seasons and it is best suited in existing cropping scheme. However, yield potential of maize is highly prone to biotic stresses. In maize, flowering is the most crucial stage in terms of negative effects of drought on yield. During this stage, one single day of drought can potentially decrease yield up to 8%. Plant populations affect most growth parameters of maize even under optimal growth conditions and therefore it is considered a major factor determining the degree of competition between plants. The field experiment was laid out split plot design with factorial design with three replications. Treatments included cut irrigation (S1: Cut irrigation in 8 leaf, S2: Cut irrigation in 12 leaf, S3: Male flower appearance, S4: Normal irrigation) and density (6 plant/m², 8 plant/m², 12 plant/m²). Analysis of variance showed that the effect of water stress and density on all characteristics was significant

Key words: Harvest Index, Biological yield, Seed yield

INTRODUCTION

Maize (Zea mays L.) production under the semi-arid conditions of the Islamic Republic of Iran during the summer requires supplemental irrigation to attain maximum yields. Maize is cultivated in both spring and autumn seasons and it is best suited in existing cropping scheme. However, yield potential of maize is highly prone to biotic stresses (Drought, salinity, extreme temperatures, flooding, pollutants & poor or excessive irradiation) which are important factors towards limiting the crop productivity (Misovic, 1985; Lawlor, 2002). Among the abiotic stresses, drought is the most severe limitation to maize production (Sallah et al., 2000). To a careful estimate, only drought reasons for 50% or more reduction in average yields worldwide (Wang et al., 2003). Water and N deficit condition, leading to a reduction in crop production by reduce resource capture and use efficiency. Several experimenters subjected maize to a water deficit during different developmental stages. It was found that both the degree and the time of stress are important in determining the final grain yield. Water deficit induces a reduction in maize tissue water contents and subsequently water potential, leaf elongation, leaf photosynthesis, and changes in protein synthesis, nitrogen metabolism and cell membrane properties, leading to a reduction in plant productivity (Bogoslavsky and Neumann, 1988, Shangguan et al., 2000, Saneoka et al., 2004, etc.). Under semi-arid environment, water deficits imposed during vegetative period (41 and 55 days after planting) reduced leaf, stalk and ear yields of maize, while water deficit during grain filling did not affect leaf and stalk yields (Eck, 1984). Maize is relatively insensitive to water deficit stress imposed during early vegetative growth stages because water demand is relatively low and plants can adapt to water stress to reduce the impact of subsequent periods of water stress (Shaw, 1977). In maize, flowering is the most crucial stage in terms of negative effects of drought on yield. During this stage, one single day of drought can potentially decrease yield up to 8% (Shaw, 1977). Water stress reduces crop yield regardless of the growth stage at which it occurs (Jensen & Mogensen, 1984). Drought causes numerous physiological and biochemical changes in plants like reduced leaf size, stem extension, root proliferation, reduced water use efficiency (Farooq et al., 2009), alteration in metabolic activities (Lawlor & Cornic, 2002), inhibition of enzymatic activities (Ashraf et al., 1995), ionic imbalance and disturbances in solute accumulation (Khan et al., 1999) or a combination of all these factors.
In maize, drought reduces leaf area, leaf chlorophyll contents, photosynthesis and ultimately lowers the grain yield (Athar & Ashraf, 2005). At flowering, drought widens the anthesis silking interval (ASI) in maize, which severely reduces the kernel set (Emeadeas et al., 2000). Under drought leaf senescence is also accelerated to decrease the canopy size (Mooney & Duplesis, 1970) severely affecting the crop yield. However delayed leaf senescence affects positively for reducing the harmful effects of drought on crop yield (Rivero et al., 2007). Doorenbos and Kassam (1979) have reported that the greatest decrease in grain yields is caused by water deficit in the soil profile during the flowering period. The accumulation of solutes to decrease water potential may allow plants to maintain a water potential gradient as the soil becomes drier and thus maintain the positive pressure potential required to keep stomata open and sustain gas exchange and growth (White et al., 2000). Protein content is significantly increased under water deficit (Guttieri et al., 2000; Ozturk and Aydin, 2004), mainly due to higher rates of accumulation of grain N and lower rates of accumulation of carbohydrates. Ozturk and Aydin (2004) observed that late water deficit stress increased grain protein and wet gluten content relative to the fully irrigated treatment. Soil–water depletion and plant water use efficiency (WUE) are critical factors affecting agricultural productivity in arid and semiarid areas around the world. Hence, various soil and crop management practices have been developed to increase crop yields (Huang et al., 2005; Fang et al., in press), notably plastic or straw mulching, which may efficiently improve the microclimate and crop growth conditions (Albright et al., 1989) by promoting plant transpiration at the expense of evaporation from the soil (Raeini-Sarjaz and Barthakur, 1997; Wang et al., 2009). Thus, both crop yields and WUE have often been reported to be increased by mulching treatments (Li et al., 2001; Li and Gong, 2002). Irrigation may also have beneficial effects on plant water relations and yields, but Kang et al. (2002) found that grain yield (GY) and WUE responses to irrigation varied considerably with differences in soil–water contents and irrigation schedules. Further, Wang et al. (2002) and Fang et al. (in press) showed that scheduled irrigation based on crop responses to water stress at different development stages can improve WUE, but Olesen et al. (2000) found that although irrigation increased yields, there were no significant differences in WUE and harvest index in wheat subjected to three different irrigation strategies, since the increases were almost solely due to increased transpiration. In addition, excessive irrigation can reduce crop WUE (Jin et al., 1999). There are a number of biotic and abiotic factors those affect maize yield considerably; however, it is more affected by variations in plant density than other member of the grass family (Vega et al., 2001). Maize differs in its responses to plant density (Luque et al., 2006). Liu et al. (2004) also reported that maize yield differs significantly under varying plant density levels due to difference in genetic potential. Correspondingly maize also responds differently in quality parameters like crude starch, protein and oil contents in grains (Munamava et al., 2006). Plant populations affect most growth parameters of maize even under optimal growth conditions and therefore it is considered a major factor determining the degree of competition between plants (Sangakkara et al., 2004). The grain yield per plant is decreased (Luque et al., 2006) in response to decreasing light and other environmental resources available to each plant (Ali et al., 2003).

Stand density affects plant architecture, alters growth and developmental patterns and influences carbohydrate production. At low densities, many modern maize varieties do not tiller effectively and quite often produce only one ear per plant. Whereas, the use of high population increases interplant competition for light, water and nutrients, which may be detrimental to final yield because it stimulates apical dominance, induces barrenness, and ultimately decreases the number of ears produced per plant and kernels set per ear (Sangoi, 2001). Hiebsch et al. (1995) stated that collective production from the component crops may be greater in intercropping than in sole cropping from a unit land area. The beneficial effects of intercropping soybean/maize have not been fully exploited by farmers in the major soybean producing areas of the southern guinea savannah agro-ecological zone (Kalu and Omojar, 1991). Many vegetative and yield variables of crops are potentially influenced by competition of the plant with the second crop in an intercropping system and by competition with other plants of the same species. This influence may be affected by changes in plant population density. One of the major constraints of soybean production has been the dearth of information on the relative plant population densities of the non-legume components where soybean is grown in the intercropping system especially in the southern guinea savannah-agro-ecosystem typified by Otukpo area of Benue State, Nigeria. Maize is an important component crop in the inter-cropping systems of the area.

MATERIAL AND METHODS

The experiment was conducted at the mirjaveh (Iran) which is situated between 29° North latitude and 30° East longitude. Composite soil sampling was made in the experimental area before the imposition of treatments and was analyzed for physical and chemical characteristics. The field experiment was laid out split plot design with factorial design with three replications.
Treatments included cut irrigation (S1: Cut irrigation in 8 leaf, S2: Cut irrigation in 12 leaf, S3: Male flower appearance, S4: Normal irrigation) and density (6 plant/m², 8 plant/m², 12 plant/m²). Data collected were subjected to statistical analysis by using a computer program MSTATC. Least Significant Difference test (LSD) at 5 % probability level was applied to compare the differences among treatments’ means.

RESULTS AND DISCUSSION

A. Harvest Index
Analysis of variance showed that the effect of water stress on harvest index was significant (Table 1). The maximum of harvest index (30.94) of treatments male flower appearance was obtained (Table 2). The minimum of harvest index (24.95) of treatments 8 leaf was obtained (Table 2). Analysis of variance showed that the effect of density on harvest index was significant (Table 1). The maximum of harvest index (30.27) of treatments 6 plant was obtained (Table 2). The minimum of harvest index (27.89) of treatments 12 plant was obtained (Table 2).

B. Biological yield
Analysis of variance showed that the effect of water stress on biological yield was significant (Table 1). The maximum of biological yield (24463.3) of treatments normal irrigation was obtained (Table 2). The minimum of biological yield (8042.8) of treatments 8 leaf was obtained (Table 2). Analysis of variance showed that the effect of density on harvest index was significant (Table 1). The maximum of biological yield (19846.6) of treatments 12 plant was obtained (Table 2). The minimum of biological yield (16133.8) of treatments 6 plant was obtained (Table 2).

C. Seed yield
Analysis of variance showed that the effect of water stress on seed yield was significant (Table 1). The maximum of seed yield (7448.1) of treatments normal irrigation was obtained (Table 2). The minimum of seed yield (5129.3) of treatments 6 plant was obtained (Table 2). The minimum of seed yield (5690.6) of treatments 12 plant was obtained (Table 2).

Table 1: Anova analysis of the corn affected by water stress and plant density.

<table>
<thead>
<tr>
<th>S.O.V</th>
<th>df</th>
<th>Harvest Index</th>
<th>Biological yield</th>
<th>Seed yield</th>
<th>Protein (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>2</td>
<td>16.847&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>74.971&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>683413&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>0.321&lt;sup&gt;ns&lt;/sup&gt;</td>
</tr>
<tr>
<td>Water stress (S)</td>
<td>3</td>
<td>77.778&lt;sup&gt;**&lt;/sup&gt;</td>
<td>451239321&lt;sup&gt;**&lt;/sup&gt;</td>
<td>50859980.4&lt;sup&gt;**&lt;/sup&gt;</td>
<td>9.281&lt;sup&gt;**&lt;/sup&gt;</td>
</tr>
<tr>
<td>Error a</td>
<td>6</td>
<td>4.719</td>
<td>153526</td>
<td>152605.5</td>
<td>0.031</td>
</tr>
<tr>
<td>Density (D)</td>
<td>2</td>
<td>7.686&lt;sup&gt;*&lt;/sup&gt;</td>
<td>41372251&lt;sup&gt;**&lt;/sup&gt;</td>
<td>947802&lt;sup&gt;**&lt;/sup&gt;</td>
<td>0.771&lt;sup&gt;**&lt;/sup&gt;</td>
</tr>
<tr>
<td>S*D</td>
<td>6</td>
<td>31.099&lt;sup&gt;**&lt;/sup&gt;</td>
<td>4922261&lt;sup&gt;**&lt;/sup&gt;</td>
<td>7401.2&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>0.074&lt;sup&gt;ns&lt;/sup&gt;</td>
</tr>
<tr>
<td>Error b</td>
<td>16</td>
<td>1.688</td>
<td>252791</td>
<td>18361.2</td>
<td>0.029</td>
</tr>
<tr>
<td>CV (%)</td>
<td></td>
<td>4.426</td>
<td>2.791408</td>
<td>2.509</td>
<td>3.492</td>
</tr>
</tbody>
</table>

*, **, ns: significant at p<0.05 and p<0.01 and non-significant, respectively.

Table 2: Comparison of different traits affected by water stress and plant density.

<table>
<thead>
<tr>
<th>Ms</th>
<th>Harvest Index</th>
<th>Biological yield</th>
<th>Seed yield</th>
<th>Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water stress</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 leaf</td>
<td>24.95b</td>
<td>8042.8d</td>
<td>2006.7d</td>
<td>3.77d</td>
</tr>
<tr>
<td>12 leaf</td>
<td>30.86a</td>
<td>18501.1c</td>
<td>5669.1c</td>
<td>4.35c</td>
</tr>
<tr>
<td>Male flower appearance</td>
<td>30.94a</td>
<td>21040b</td>
<td>6482.3b</td>
<td>5.49b</td>
</tr>
<tr>
<td>Normal irrigation</td>
<td>30.67a</td>
<td>24463.3a</td>
<td>7448.1a</td>
<td>5.98a</td>
</tr>
<tr>
<td>Density</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 plant</td>
<td>30.27a</td>
<td>16133.8c</td>
<td>5129.3b</td>
<td>4.69b</td>
</tr>
<tr>
<td>8 plant</td>
<td>29a</td>
<td>18055.1b</td>
<td>5384.8b</td>
<td>4.82b</td>
</tr>
<tr>
<td>12 plant</td>
<td>27.89a</td>
<td>19846.6a</td>
<td>5690.6a</td>
<td>5.8a</td>
</tr>
</tbody>
</table>

Any two means not sharing a common letter differ significantly from each other at 5% probability.
D. Protein

Analysis of variance showed that the effect of water stress on protein was significant (Table 1). The maximum of protein (5.98) of treatments normal irrigation was obtained (Table 2). The minimum of protein (3.77) of treatments 8 leaf was obtained (Table 2). Analysis of variance showed that the effect of density on protein was significant (Table 1). The maximum of protein (5.8) of treatments 12 plant was obtained (Table 2). The minimum of protein (4.69) of treatments 6 plant was obtained (Table 2).

REFERENCES


