Yield responses of maize as influenced by supplemental foliar applied phosphorus under drought stress

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Abstract

Drought is one of the most serious problems posing a grave threat to cereals production including maize. A field study was conducted to evaluate the effect of foliar applied phosphorus at 8 kg ha⁻¹ at 8th leaf stage on yield and yield components of four maize hybrids i.e two drought tolerant (6525, 32B33) and two drought sensitive (Hycorn and 31P41) under normal and water stress conditions. RCBD with factorial arrangement were employed to lay out the experiment with a net plot size of 4.75 m x 5 m with three replications at research area of Agronomy, Department of Agronomy, University of Agriculture Faisalabad, Pakistan. The foliar applied phosphorus @ 8 kg ha⁻¹ at 8th leaf stage of maize significantly affect the yield and yield parameters in both drought tolerant and sensitive hybrids. The water stress decreased the 1000-grain weight (21.2%), grain yield (21.3%) and biological yield (22.4%) as compared to normal irrigation. The both drought tolerant hybrids of maize (6525 and 32B33) performed better than drought sensitive hybrids (Hycorn and 31P41) under normal and water stress conditions.

1. Introduction

Food is the basic requirement of life and is a mean for the growth and development of living organisms. In many developing countries the water stress is the major constraint to agricultural production and also reduced the quality, growth and production of crops (Hongbo, Zongsuo, & Mingan, 2005; Golbashy et al., 2010; Waraich et al., 2010, 2011; Ahmad et al., 2015). In arid and semi-arid regions of the world the water stress seriously cause problems by limits the agriculture production. The life cycle of different plants usually affected by water stress and plants face water deficit from atmosphere and soils during its life cycle (Chaves et al., 2002). Cakir (2004) stated that water stress during different corn growth stages decreases yield in different degrees of intensity. The decrease of yield depends on both stress severity and plant growth stage. Rezaverdinejad, Sohrabi, & Liaghat (2006) stated that the drought condition at vegetative as well at reproductive stage of the corn reduced yield 28% to 29 %. Pandey, Maranville, & Chetima (2000) stated that deficit irrigation at early vegetative growth, slightly decrease leaf area index, plant height, plant growth rate and dry matter in corn. Maize yield is closely associated with the physiological condition of the crop during the critical period. The association of water availability is positive while growth as well as yield of crop is influenced with the limited supply of water (Andrade et al., 2002; Rimski-Korsakov, Rubio, & Lavado, 2009). Sasidharan (2005) conducted a genetic analysis for yield and quality attributes in castor under irrigated (E1) and un-irrigated (E2) conditions and concluded yield and yield components excelled under normal condition. Ti-da et al. (2006) performed a research in maize under field condition and concluded that grain per cob and 1000 grain weight of maize reduced under water stress condition. As a result the yield of maize also reduced under drought stress condition.

The major nutrients such as NPK are used for foliar fertilization in different crops for improving the growth and yield of crops. The quality as well the yield of crops are enhanced by foliar application of NPK (Römhild & El-Fouly, 1999). The foliar application of P and Zn significantly enhanced the cob index and starch contents.
of maize but the dry matter production of maize was not affected (Leach & Hameleers, 2001). Phosphorus (P) is the 2nd major nutrient after nitrogen (N) and it is deficit in soils. The growth and yield of many field crops are enhanced by the application of P and also increased the root growth in many crops under water stress condition (Yaseen & Malhi, 2009). For instance, 90% of soils are deficient in nitrogen (N) and phosphorus (P) and 40% in potassium in (Ahmad & Rashid, 2004). Among all the nutrient elements required by a plant, P has prime importance for crop production and emphasis is being given on the efficient use of P fertilizers for sustainable crop production (Ryan, 2002). It is investigated by the different scientists that the additional dose of P is used to increase the over-all production of crops in soil (Shah et al., 2006; Jabran et al., 2011). The phosphorus application decreases the effect of drought in crops (Singh et al., 1981). Phosphorus is an essential element for all living organisms and involved in nucleic acid and phospholipids synthesis. It also activates many enzymes (Lambers et al., 2006). Phosphorus also plays a key role in energy transfer and is thus essential for photosynthesis under drought condition. The deficiency of P causes net photosynthesis reduction and decreased shoot and root biomass production in maize crop (Wissuwa, Gamat, & Ismail, 2005). Leaf growth depression under P deficiency is well documented (Kavanova et al., 2006). Phosphorus deficiency affects the rate of emergence and number of maize adventitious nodal roots (Pellerin, Mollier, & Plenet, 2000; Kavanova et al., 2006). Girma et al. (2007) stated that the phosphorus use efficiency (PUE) and yield was enhanced by foliar applied phosphorus. The nine experiments were conducted at different places (Efaw, Goodwell, Guymon, Lake Carl Blackwell, Perkins and Stillwater) in 2002 and 2003. These experiments were conducted to observed foliar application of phosphorus at different growth stages [$V_4$ (Collar of fourth leaf visible), $V_5$ (Collar of eighth leaf visible) and VT (Last branch of the tassel completely visible but silks not yet emerged)] of maize. Results showed that the foliar P at 8 kg ha$^{-1}$ applied at $V_5$ (Collar of eighth leaf visible) growth stages and later, was performed best than all others growth stages of maize.

Maize is the third important cereal crop in the world after wheat and rice on the basis of area and production (Tollenaar & Dwyer, 1999). The maize grain also used for the food and feed propose for livestock as well as for the poultry. Manu products of maize such as corn flour, pop corns, gruels, porridges, bread, beverages, snacks and pastes use for the consumption of human (Ortiz-Monasterio et al., 2007; Menkir, 2008). Increasing importance of maize in human food and nutrition could be estimated by its global average production of 780 million tonnes during the year 2007-08. Maize added 22.2% in Agriculture and 0.5% to GDP in Pakistan. In last year 0.2% maize crop was grown in less area but its production 6.85 was increased. The yield per hectare in 2012-13 stood at 4268 (Kg ha$^{-1}$) posted a positive growth of 6.9% as compared to 4.9% growth last year. The production of maize is enhanced due to using hybrid seeds and favourable environmental condition (Govt. of Pakistan, 2014). Many research performed work which are related to soil applied P, however very little information is available on the combine effect of foliar applied and soil applied phosphorus in alleviating the adverse effect of drought stress especially in maize. The present study will be, therefore, carried out with the following objectives: to assess the effect of supplemental foliar applied phosphorus on yield and yield components of hybrid maize grown under normal and water stress conditions.

2. Materials and methods

2.1. Experimental site and conditions

Experiment was conducted at farm of Department of Agronomy, University of Agriculture, Faisalabad, Pakistan. The supplemental foliar applied KH$_2$PO$_4$ (Potassium phosphate) at 8 kg ha$^{-1}$ at 8th leaf stage was applied by using two droughts tolerant (6525 & 32B33) and two drought sensitive (31P41 and Hycorn) maize hybrids. The experiment was laid out in RCBD factorial arrangement.

2.2. Crop husbandry

The study was conducted in March (spring maize growing season in Pakistan) during the year 2014. The seeds were obtained from Maize and Millet Research Institute (MMRI) Yousaf Wala Sahiwal and local market of Sahiwal, Pakistan. The seed rate 10 kg acre$^{-1}$ was used for sowing. All the recommended dose of NPK was applied at the time of sowing. Hygrometric method was used to determine the texture of soil (Dewis and Freitas, 1970). The Electrical conductivity, pH and ion contents of the soil used for this study were determined according to methods described by Jackson (1962) and are present.
in Table 1. The weather in respect of minimum and maximum (°C), relative humidity (%) and rainfall (mm) of the experimental site for the year 2014 is given in the Fig. 1. Foliar application of P at 8 kg ha\(^{-1}\) was applied at 8\(^{th}\) leaf stage of maize by skipping irrigation. The weeds of maize crop were controlled by manually by hoeing. Insecticides were applied two times, as and when required, to control the insect pest of maize. All agronomist practices were uniform for all the treatments. Harvesting was done after 110 days of sowing 2014.

Table 1. Physiochemical characteristics of the soil used for field experiment

<table>
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<tr>
<th>Soil Characteristics</th>
<th>Values</th>
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<tbody>
<tr>
<td><strong>Physical</strong></td>
<td></td>
</tr>
<tr>
<td>Soil texture</td>
<td>Sandy clay loam</td>
</tr>
<tr>
<td>Saturation percentage (%)</td>
<td>37.6</td>
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<tr>
<td>EC(_e) (dSm(^{-1}))</td>
<td>0.72-0.92</td>
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<tr>
<td>Soil pH(_s)</td>
<td>7.5-7.8</td>
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<tr>
<td>Organic matter (%)</td>
<td>0.4-0.6</td>
</tr>
<tr>
<td>Ca+Mg (meq L(^{-1}))</td>
<td>3.75-5.76</td>
</tr>
<tr>
<td>CO(_3) (meq L(^{-1}))</td>
<td>Nil</td>
</tr>
<tr>
<td>HCO(_3) (meq L(^{-1}))</td>
<td>3.5-4.0</td>
</tr>
<tr>
<td>Available P (mg kg(^{-1}))</td>
<td>8.2-10.8</td>
</tr>
</tbody>
</table>

Figure 1. Meteorological data of the experimental site for the growing seasons 2014

2.3. Data collection

The data of all yield and yield related parameters (cob length, number of cobs per plant number of grains per cob, cob weight without sheath, 1000-grain weight, grain yield, biological yield and harvest index) were calculated from the five tagged plant. The cob length, number of cobs per plant, number of grains per cob was calculated by counting from five tagged plant in each plot. Average cob weight without sheath and 1000-grain weight was calculated by electric balance. All the cobs from plants of each plot were separated and then shelled with the help of Sheller and grains were weighed to have grain yield, then grain yield is converted to t ha\(^{-1}\). Similarly Biological yield contains Stover, pith and grain yield. Crop was harvested from each plot manually, dried under sun and weighed to determine the biological yield in kg per plot and then converted to this biological yield to t ha\(^{-1}\). The harvest index (HI) was calculated by using formula.

Economic yield (grain yield)  

\[
\text{HI (\%)} = \frac{\text{Economic yield (grain yield)}}{\text{Biological yield (grain + straw)}} \times 100
\]

The recorded data were analyzed statically using analysis of variance technique by using MSTAT-C software. Least significant difference (LSD) test at 5% probability level was used to compare the significant mean.

3. Results

3.1. Cob length (cm)

Drought stress significantly reduced (P<0.001) the cob length (Table 1a). The water deficit conditions at 8\(^{th}\) leaf stage significantly decreased it by 5.9% as compared to normally irrigated (control) plants. The maximum cob length (19.01 cm) was observed under normal condition while minimum cob length (17.87 cm) of maize was recorded under stress condition. Maize hybrids 6525 and 32B33 maintained 6.7% and 5.9% more cob length than 31P41 and Hyicorn under normal and stress conditions (Fig. 1). The effect of supplemental foliar applied P spray treatment was also highly significant (P<0.001) for cob length. The foliar application of P spray at 8\(^{th}\) leaf stage increased the cob length (18.79 cm) as compare to no spray (18.10 cm) treatment (Figure 2). All the interactions such as H x T and H x W x T were non-significant (Table 1a).

3.2. Number of cobs per plant
The number of cobs per plant was significantly (P<0.01) decreased by water stress in all four maize hybrids (Table 1a). The decrease in number of cobs plant$^{-1}$ was more pronounced in water stressed plants as compared to normal irrigated plants. The water stress at 8th leaf stage of maize reduced number of cobs plant$^{-1}$ by 37.5% as compared to normally irrigated plants. The maximum number of cobs plant$^{-1}$ (6.66) was recorded under well watered condition while minimum number of cobs plant$^{-1}$ (5.58) of maize was recorded under stress conditions. Similarly the maize hybrids 6525 and 32B33 performed better than 31P41 and Hycorn. Figure 3 showed that the more number of cobs per plants were observed in hybrid 6525 (6.50) while in hybrid Hycorn (5.66) have low number of cobs per plant. The effect of supplemental foliar applied P spray treatment was also highly significant (P<0.001) for number of cobs plant$^{-1}$. The foliar application of P spray at 8th leaf stage increased the number of cobs plant$^{-1}$ (5.48) as compare to no spray (5.70) treatment (Figure 3).

All the interactions such as H x T and H x W x T were non-significant (Table 1a).

3.3. Number of grains per cob

Drought stress significantly reduced (P<0.001) the number of grains cob$^{-1}$ in all four maize hybrids (Table 1a). The water deficit conditions at 8th leaf stage significantly decreased number of grains cob$^{-1}$ by 3.9% as compared to normally irrigated (control) plants. The more number of grains cob$^{-1}$ (376.38) was observed under well watered condition while minimum number of grains cob$^{-1}$ (361.79) of maize was recorded under stress conditions. Maize hybrids 6525 and 32B33 maintained 3.8% and 3.7% more number of grains cob$^{-1}$ than 31P41 and Hycorn respectively. The maximum number of grains cob$^{-1}$ in hybrid 6525 (372.17) was observed while the minimum number of grains cob$^{-1}$ (366.42) was observed in Hycorn (Figure 4). The effect of supplemental foliar applied P spray treatment was also highly significant (P<0.001) for number of grains cob$^{-1}$. The foliar application of P spray at at 8th leaf stage increased the number of grains cob$^{-1}$ (372.54) as compare to no spray (365.63) treatment (Figure 4).

All the interactions such as H x T and H x W x T were non-significant (Table 1a).

3.4. Cob weight without sheath (g)
Figure 4. Effect of supplemental foliar P application on number of grains per cob of four maize hybrids under different water levels (mean values ± S.E).

The cob weight without sheath was significantly \( (P<0.01) \) decreased by water stress in all four maize hybrids (Table 1a). The decrease in cob weight without sheath was more pronounced in water stressed plants. The water stress at 8th leaf stage reduced cob weight without sheath by 20.3% as compared to normally irrigated plants (Figure 5). The maximum cob weight without sheath (225.38 g) was observed under normal condition while minimum cob weight without sheath (179.71 g) of maize was recorded under stress conditions. Maize hybrids 6525 and 32B33 performed better than 31P41 and Hycorn. The maximum cob weight without sheath in hybrid 6525 (213.31 g) was observed while the minimum cob weight without sheath (193.35 g) was observed in Hycorn (Figure 5). The effect of supplemental foliar applied P spray treatment was also highly significant \( (P<0.001) \) for cob weight without sheath. The foliar application of P spray at 8th leaf stage increased the number of cob weight without sheath (214.53 g) as compare to no spray (190.56 g) treatment (Figure 5).

All the interactions such as H x T and H x W x T were non-significant (Table 1a).

Figure 5. Effect of supplemental foliar P application on number of grains per cob of four maize hybrids under different water levels (mean values ± S.E).

3.5. Thousand grain weight (g)

Drought stress significantly reduced \( (P<0.001) \) the thousand grain weight in all four maize hybrids (Table 1b). The water deficit conditions at 8th leaf stage significantly decreased thousand grain weights by 21.2% as compared to normally irrigated (control) plants (Figure 6). The maximum value of thousand grain weights (270.70 g) was observed under normal condition while minimum thousand grain weight (213.47 g) of maize was recorded under stress conditions. Maize hybrids 6525 and 32B33 maintained 23.2% and 22.3% more thousand grain weight than 31P41 and Hycorn respectively. The maximum thousand grain weight (253.76 g) was observed in hybrid 6525 while the minimum thousand grain weight (229.35 g) was observed in Hycorn (Fig. 5). The effect of supplemental foliar applied P spray treatment was also highly significant \( (P<0.001) \) for thousand grain weight. The foliar application of P spray at 8th leaf stage increased the thousand grain weight (258.28 g) as compare to no spray (225.88 g) treatment.
Figure 6. Effect of supplemental foliar P application on 1000-grain weight (g) of four maize hybrids under different water levels (mean values ± S.E)

(Figure 6). The interaction between maize hybrids and treatments were significantly affecting the thousand grain weight under normal and stress conditions. The highest thousand grain weight was recorded in 6525 (272.60 g) where supplemental foliar applied P @ 8 kg ha⁻¹ at 8th leaf stage while minimum thousand grain weight observed in Hycorn (216.23 g) where no foliar spray under normal and stress conditions (Figure 6). All others interactions were non-significant (Table 1b).

3.6. Grain yield (t ha⁻¹)

The grain yield was significantly (P<0.01) decreased by water stress in all four maize hybrids (Table 1b). The decrease in grain yield was more pronounced in water stressed plants. The water stress at 8th leaf stage reduced grain yield by 21.3% as compared to normally irrigated plants (Figure 7). The maximum grain yield (6.77 t ha⁻¹) was recorded under normal condition while minimum grain yield (4.62 t ha⁻¹) of maize was recorded under stress conditions. Maize hybrids 6525 and 32B33 performed better than 31P41 and Hycorn. The maximum grain yield (6.15 t ha⁻¹) was observed in hybrid 6525 while the minimum grain yield (5.30 t ha⁻¹) was observed in Hycorn (Figure 7). The effect of supplemental foliar applied P spray treatment was also highly significant (P<0.001) for grain yield. The foliar application of P spray at 8th leaf stage increased the grain yield (6.27 t ha⁻¹) as compare to no spray (5.12 t ha⁻¹) treatment (Figure 7).

All the interactions such as H x T and H x W x T were non-significant (Table 1b).

3.7. Biological yield (t ha⁻¹)

Drought stress significantly reduced (P<0.001) the biological yield in all four maize hybrids (Table 1b). The water deficit conditions at 8th leaf stage significantly decreased biological yield by 22.4% as compared to normally irrigated (control) plants (Figure 8). The more biological yield (16.54 t ha⁻¹) was observed under normal condition while minimum biological yield (12.83 t ha⁻¹) of maize was recorded under stress conditions. Maize hybrids 6525 and 32B33 maintained 23.1% and 22.9% more biological yield than 31P41 and Hycorn respectively (Figure 8). The effect of supplemental foliar applied P spray treatment was also highly significant (P<0.001) for biological yield. The foliar application of P
spray at 8th leaf stage increased the biological yield (15.68 t ha⁻¹) as compared to no spray (13.69 t ha⁻¹) treatment. The maximum biological yield (15.52 t ha⁻¹) was observed in hybrid 6525 while the minimum biological yield (13.91 t ha⁻¹) was observed in Hycorn (Figure 8). The interaction between maize hybrids and treatments were significantly affecting the biological yield under normal and stress conditions. The highest biological yield was recorded in 6525 (16.63 t ha⁻¹) where supplemental foliar applied P @ 8 kg ha⁻¹ at 8th leaf stage while minimum biological yield observed in Hycorn (12.87 t ha⁻¹) where no foliar spray under normal and stress conditions (Figure 8).

All others interactions were non-significant (Table 1b).

3.8. Harvest index (%)

The harvest index was significantly (P<0.01) decreased by water stress in all four maize hybrids (Table 1b). The decrease in harvest index was more pronounced in water stressed plants. The water stress at 8th leaf stage reduced harvest index by 12.2% as compared to normally irrigated plants (Figure 9). The maximum harvest index (40.86%) was observed under normal condition while minimum harvest index (35.90%) of maize was recorded under stress conditions. Maize hybrids 6525 and 32B33 performed better than 31P41 and Hycorn under normal

4. Discussion

The yield and yield components of the crops are reduced under drought stress condition (Baser et al., 2004). An obvious reduction in cob weight, number of grains per cob, 1000-grain weight, biological yield and grain yield under water stress conditions for all maize hybrids was observed. Foliar application of P at 8th leaf stage positively affected the yield parameters. Foliar application of P enhanced yield of wheat (dos Santos et al., 2004). The uptakes of the different nutrients are also low under drought stress condition and plant leaves were symptomatic of nutrient deficiency. At organ level, in such conditions, the plant leaf are responsible for photosynthesis and under drought condition the leaf are reduced as well as remain small (Fricke et al., 1997). As a result the plant growth, uptake of plant nutrients and yield of crop are reduced.
Table 1 (a,b). Analysis of variance table for cob length, number of cobs plant\(^{-1}\), number of grains cob\(^{-1}\), cob weight without sheath, thousand grain weight (g), grain yield (t ha\(^{-1}\)) and biological yield (t ha\(^{-1}\)) of four maize hybrids in well-watered and water stress conditions with supplemental foliar applied phosphorus*, **, *** = Significant at 0.05, 0.01 and 0.001 level respectively, NS = Non significant

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<tr>
<td></td>
<td>Cob length (cm)</td>
<td>No. of cobs per plant</td>
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<td>Hybrids (H)</td>
<td>***</td>
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<td>Water levels (W)</td>
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<td>Treatments (T)</td>
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<td>H x W</td>
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<td>H x W x T</td>
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Benbella & Paulsen (1998) stated that the foliar applied P (5 to 10 kg KH\(_4\)PO\(_4\) ha\(^{-1}\)) after anthesis stage enhanced the grain yield of wheat up to 1 Mg ha\(^{-1}\). The total number of fertile tillers of wheat increase when P was applied at early growth stage (Elliot et al., 1997; Grant et al., 2001). Mosali et al. (2006) recognized Zadoks 32 (i.e. when second node is detectable during stem elongation) as the best time for the application of P by enhancing the grain yield of wheat and uptake of P. Grain yields of corn positively responded to P at 2 kg ha\(^{-1}\) applied as foliar spray from eighth leaf through to tasselling growth stages (Girma et al., 2007). Arif et al. (2006) studied the response of foliar applied P at tellering stage of wheat (Zadoks stage 26; main shoot and six tillers) and at booting (Zadoks stage 47; flag sheath opening) with one, two or three applications of the nutrient mix. Gooring & Davies (1992) reported that foliar applications at or 2 weeks following anthesis can be of greater benefit compared to soil applied fertilization. Multiple beneficial effects of foliar P fertilizer application in corn (Thavaprakaash, Velayudham, & Panneerselvam, 2006), wheat (Batten, Wardlaw, & Aston, 1986) and barley (Qaseem, Afridi, & Samiullah, 1978) have been documented. Leach & Hameleers (2001), observed a significant increase in both cob index and starch content when P was applied at four-leaf growth stage. Batten, Wardlaw, & Aston (1986) reported that foliar application of KH\(_4\)PO\(_4\) resulted in higher grain yield in winter wheat coupled with the delay in leaf senescence in hot and dry growing conditions. The supplemental foliar applied P enhanced the number of grains per cob. They argued that less number of cobs plant\(^{-1}\) in the control plots resulted in less number of grains plant\(^{-1}\) that finally resulted in minimum grain yield. The results are in accordance with those of Sharma & Sharma (1991) who reported that P fertilizer applications significantly affected the grains per cob. The results were similar with that of Maqsood et al. (2001) and Leon (1999) who reported that number of grains cob\(^{-1}\) were influenced significantly with NP application. Arain, Aslam, & Tunio (1989) reported that number of grains per cob of maize increased with increase in P application. Fareed (1996) and Hussain et al. (2006) observed an increase in 1000-grain weight with increase in NP application. Phosphorus being responsible for good root growth directly affected the thousand grain weight because P at the rate of 0 kg ha\(^{-1}\) (control plots) resulted in the least thousand grain weight (Hussain et al., 2006).

In the present study the foliar applied at 8\(^{th}\) leaf stage enhanced the grain yield of maize. Similar result given by the Giskin & Efron (1986), they conducted a field experiment to study the response of foliar applied P. Concluded that the foliar applied P increased the grain yield.
yield up to 16.6%. Ahmed et al. (2006) stated that the foliar application of different nutrients solutions having different percentage (9% P with 12% N, 8% K, 1% zinc, 2% iron, 1.5% manganese, 3% magnesium, 1.4% copper, 2.3% S and 0.05% boron) they also stated that the plants treated with the different nutrients solution having more P as compared to without treated plants. In the field study by Mosali et al. (2006), stated that the almost 50% of experiment indicated significant yield with the application of P and these response was present when plant treated with the foliar applied P. Similarly in the studies of Girma et al. (2007), indicated that the foliar applied P enhanced the grain yield. Arain, Aslam, & Tunio, (1989) reported that number of cobs per plant of maize increased with increase in P application. The soil application of P increased the grain yield in maize (Arain, Aslam, & Tunio, 1989). The supplemental foliar applied increased the grain yield of maize under drought condition. The increase in grain yield due to NP application was also reported by Khan et al. (1999), Maqsood et al. (2001) and Sharma & Sharma (1991). Arain, Aslam, & Tunio (1989) reported that grain yield of maize increased with increase in P application.

5. Conclusions

Against the background of decreasing water availability and the need for hybrids, able to withstand water-limited environments, we found that foliar spray P @ 8 kg ha⁻¹ treatment at 9th leaf stage of maize was the most effective in terms of improving plant growth and yield, not only under well-watered conditions but also under water-stress conditions though to a lesser extent. This means that supplemental foliar fertilisation with foliar sprays can help correcting nutrient deficiencies in water-limited environments where nutrient uptake is generally limited.

Acknowledgements

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References


Yield of Zea mays, 46:


