EFFECT OF NITROGEN LEVELS AND WEED-CROP COMPETITION DURATIONS ON YIELD AND YIELD COMPONENTS OF MAIZE*

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ABSTRACT

Effect of different nitrogen levels and weed-crop competition durations on yield and yield components of maize was evaluated at Post Graduate Agricultural Research Station, University of Agriculture, Faisalabad, Pakistan during 2005 and 2006 kharif seasons. The objective was to determine the critical period of weed-crop competition in maize crop under different fertility levels. In this study, naturally occurring population of weeds was allowed to compete with maize crop for 0 (weed free throughout growing season), 2, 3, 4, 5 and 15 weeks (weedy throughout growing season). Three nitrogen levels (150, 200 and 250 kg/ha) were used. The results revealed that weed free plots fertilized at 250 kg N produced higher grain yield (7.79 t/ha) against the significantly minimum grain yield (2.60 t/ha) from the plots fertilized at 150 kg N and remained weedy throughout crop growth period. Nitrogen levels and weed-crop competition durations significantly affected plant height, grains number per cob, time taken to 50 percent tasseling, time taken to 50 percent silking, number of rows per cob and number of cobs per plant. These parameters finally contributed towards grain yield. It was concluded that under low nitrogen levels, intensive weed control efforts are required to minimize weed-crop competition compared with higher nitrogen applications.

KEYWORDS: Zea mays L.; nitrogen fertilizer; weeds; agronomic characters; Pakistan.

INTRODUCTION

In Pakistan, maize (Zea mays L.) is the third most important cereal crop after wheat and rice. It is grown on an area of 1.015 million hectares, of which 98 percent is grown in Punjab and Khyber Pakhtunkhwa. The total annual production is 3.313 million tons with an average grain yield of 3.264 tons per hectare (7). Maize is used in diversified products such as corn oil, glaxose-D,

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starch, flakes, custard and other by-products like lactic acid, alcohol and acetone.

Weeds infestation reduces the yield of various crops by 15 to 100 percent and also deteriorates quality of produce (9). Farmers are aware of losses caused by insects and diseases but they pay little or no attention to weed control. Weed infestation takes away about 3.4 million tons domestic production of cereals only (wheat, rice, maize, millet and sorghum), causing an enormous loss of around Rs.10 billions per annum in Pakistan (1). Maize crop is very sensitive to weeds competition and this competition may even result in crop failure. The longer the weeds remain in competition with crop, the greater is the damage caused to the crop (6). Weeds compete for essential nutrients and decrease the crop yield even at high rate of fertilization (31). In contrast to these findings, Alkamper (5) pointed out that an increased rate of fertilizer increased the maize yield inspite of presence of weeds. Reddy (24) deserved that maize crop is more sensitive to weed competition during early growth period due to its slow growth in first 3-4 weeks. The time of weed removal is important as competitiveness of weeds depends upon duration of its interference with the crop (4).

There is optimum requirement of nutrients for maize during critical period of growth and weeds control during this period is essential to avoid economic losses. There is need to explore the critical period in weed crop interference which seriously limits crop yield. This will help in economic utilization of applied inputs. Operations performed before and after the critical periods are of less economic importance and the investment made do not pay significant returns (29). Proper time of weed removal and nitrogen application may minimize the adverse effects of weed competition on grain quality of maize and reduction in nitrogen use may create the need for more intensive weed management (12).

The present study was conducted to determine the critical period of weed-crop competition in maize crop under different fertility levels and its effect on yield and yield components

**MATERIALS AND METHODS**

This study was conducted at Post Graduate Agricultural Research Station, University of Agriculture, Faisalabad, Pakistan during kharif 2005 and 2006. The experimental soil belonged to Lyallpur Soil Series (Aridsol fine-silty, mixed, hyperthermic ustalfic, haplargid in USDA classification and Haplic
Effect of nitrogen and weed-crop competition in maize vermisols in FAO classification scheme. The pH of soil paste and organic matter were 8.4 and 0.99 percent, respectively. The site was normal from salinity / sodicity point of view and was deficient in organic nitrogen and phosphorous while it was well equipped with available potassium ranking it as medium type of soil. Meteorological data for both growing seasons (2005 and 2006) obtained from Crop Physiology Section, Agronomic Research Institute, AARI, Faisalabad are presented in Fig below.

![Meteorological data](image)

Fig. 1 Meteorological data during crop growing seasons of the year 2005 and 2006.

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Three nitrogen levels (150, 200 and 250 kg/ha) keeping 150 kg as control and six weed-crop competition durations viz: 0 (weed free throughout the growing season), 2, 3, 4, 5 and 15 weeks (weedy throughout growing season) were maintained. Layout system was randomized complete block design with split plot arrangement having four replications. Nitrogen levels were considered less important in this experiment and were kept in main plots and weed-crop competition durations considered more important and were kept in sub-plots measuring 2.7 m x 7.0 m. Maize crop (hybrid 30-Y-87) was sown on a well-prepared seedbed on 2nd and 6th August in 2005 and 2006, respectively. The crop was sown at 67.5 cm row spacing with a manually operated dibbler maintaining 22.5 cm plant to plant distance throughout the experiment. The experiment was hand planted to achieve a plant population of about 66,000 plants per hectare. Also to ensure desired plant stand in each treatment, two seeds were dropped per hill. Thinning was done when the plants reached at four leaf stage. Before the seedbed preparation, a pre-soaking irrigation of 10 cm was applied during both years. Overall, eight irrigations (7.5 cm each) were applied as and when required at different plant growth and development stages, until the crop attained physiological maturity. Fertilizer was applied @ 100 kg P₂O₅ and 100 kg K₂O per hectare in the form of diammonium phosphate and potassium sulphate, respectively. Nitrogen was applied as per treatment in the form of urea in respective plots. The whole of phosphorus and potash and 1/3rd of nitrogen was applied as basal dose. The remaining 2/3rd of nitrogen was applied in two equal splits at knee high and flowering stage (as top dressing) as per treatment schedule. Each plot was kept weeds free as per treatment schedule by manual hoeing with the help of a hand hoe (khurpa) during crop growth period. Carbofuran (Furadan 3-G @ 0.6 kg a.i/ ha) was applied twice, first after thinning of crop and second at knee high stage to protect the crop from Ostrinia nubilalis and Atherigona soccata. Crop was harvested manually on November 12 and November 15 during 2005 and 2006, respectively. Each year the harvested crop was kept in the field for two days for sun-drying. Then it was tied into bundles and stalked for four weeks. The cobs were then separated and sun-dried for 30 days before shelling. Data regarding phenological development, yield and yield components were recorded and subjected to analysis of variance (ANOVA). Least significant difference test was used for mean separation (28).

RESULTS AND DISCUSSION

Plant height

Nitrogen application at different levels had significant effect on maize plant height (Table 1). Average of two years data revealed that nitrogen applied @
250 kg produced significantly taller plants (223.85 cm) than those of 200 and 150 kg N (210.15 and 202.45 cm). Cathcart and Swanton (10), El-Hattab et al. (11) and Evans et al. (12) also reported similar findings. Two years average data also showed significant effect on maize plant height in response to weed-crop competition durations. The plots kept weed free throughout the growing season (P6) produced taller plants (236.28 cm). There was a linear decrease in plant height with increase in weed-crop competition duration. These results confirm the findings of Gab-Alla et al. (13). Interaction between nitrogen levels and weed-crop competition durations was non-significant (Table 1).

Grains weight per cob

Grains weight per cob was significantly affected by different N levels (Table-1). Nitrogen applied @ 250 kg produced maximum grains weight per cob (115.99 g) against minimum by 150 kg N (98.27 g). Similar results were also reported by Evans et al. (12). In case of weed-crop competition duration the highest grains weight per cob (126.84 g) was recorded when maize plots were kept weed free throughout the growing season (P6). However, it was statistically similar to P1 (121.32 g) where weeds were allowed to compete for two weeks. Minimum grains weight per cob (85.51 g) was produced when maize plots were kept weedy throughout the growing season (P5). These results are similar to those of Hatam and Khattak (14).

Time taken to 50 percent tasseling

Effect of interaction between nitrogen levels and weed-crop competition durations on time taken to 50 percent tasseling was non-significant (Table 1). Nitrogen levels and weed-crop competition durations independently had a significant effect on this trait. A significant increase in time taken to 50 percent tasseling (50.20 days) was observed in response to 250 kg N (N3) over 150 kg N (N3) (47.37 days). However, 250 (N3) and 200 kg N (N2) showed statistically the same response. Other workers (9, 25) have also reported delay in tasseling with increased application of nitrogen. This might be attributed to prolonged vegetative growth. Weed free plots (P6) delayed tasseling by 4.67 days compared with no weeding (P5). However, it was statistically at par with P2 and P3 where crop was allowed to compete with weeds for 2 and 3 weeks. These results are in line with Gab-Alla et al. (13).
Table 1. Effect of nitrogen levels and weed-crop competition durations yield and yield components of maize.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height (cm)</th>
<th>Grain weight/cob (g)</th>
<th>Time taken to 50% tasseling (days)</th>
<th>Time taken to 50% silking (days)</th>
<th>Number of rows/cob</th>
<th>Number of cobs/ plant</th>
<th>Grain yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Nitrogen levels(kg/ha)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N₁ = 150</td>
<td>202.45c</td>
<td>98.27b</td>
<td>47.37b</td>
<td>49.59b</td>
<td>13.37b</td>
<td>1.11b</td>
<td>5.61c</td>
</tr>
<tr>
<td>N₂ = 200</td>
<td>210.15b</td>
<td>109.66a</td>
<td>48.94ab</td>
<td>50.85ab</td>
<td>14.40ab</td>
<td>1.17ab</td>
<td>6.30b</td>
</tr>
<tr>
<td>N₃ = 250</td>
<td>223.85a</td>
<td>115.99a</td>
<td>50.20a</td>
<td>52.24a</td>
<td>15.46a</td>
<td>1.24a</td>
<td>6.65a</td>
</tr>
<tr>
<td>LSD 5%</td>
<td>4.35</td>
<td>9.49</td>
<td>1.66</td>
<td>2.18</td>
<td>1.27</td>
<td>0.07</td>
<td>0.18</td>
</tr>
<tr>
<td>(b) Weed-crop competition durations (WAS)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P₁ = 2</td>
<td>225.66b</td>
<td>121.32ab</td>
<td>50.35a</td>
<td>52.27a</td>
<td>15.18a</td>
<td>1.22b</td>
<td>7.06b</td>
</tr>
<tr>
<td>P₂ = 3</td>
<td>217.50bc</td>
<td>112.17bc</td>
<td>49.32ab</td>
<td>51.14ab</td>
<td>14.64ab</td>
<td>1.20bc</td>
<td>6.74c</td>
</tr>
<tr>
<td>P₃ = 4</td>
<td>211.40cd</td>
<td>104.54cd</td>
<td>48.55b</td>
<td>50.45bc</td>
<td>14.18b</td>
<td>1.13bcd</td>
<td>6.16d</td>
</tr>
<tr>
<td>P₄ = 5</td>
<td>203.78d</td>
<td>97.46de</td>
<td>47.78bc</td>
<td>49.74bc</td>
<td>13.76bc</td>
<td>1.09cd</td>
<td>5.43e</td>
</tr>
<tr>
<td>P₅ = 15 (Full season competition)</td>
<td>186.49e</td>
<td>85.51e</td>
<td>46.17c</td>
<td>49.09c</td>
<td>13.18c</td>
<td>1.05d</td>
<td>3.76f</td>
</tr>
<tr>
<td>P₆ = 0 (Weed free control)</td>
<td>236.28a</td>
<td>126.84a</td>
<td>50.84a</td>
<td>52.67a</td>
<td>15.53a</td>
<td>1.34a</td>
<td>7.42a</td>
</tr>
<tr>
<td>LSD 5%</td>
<td>9.86</td>
<td>3.18</td>
<td>1.62</td>
<td>1.65</td>
<td>0.97</td>
<td>0.12</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Interaction NS 0.26

Any two means not sharing a common letter differ statistically at 5% probability level. WAS = Weeks after sowing, NS = Non-significant, LSD = Least significance difference.

Time taken to 50 percent silking

The data (Table 1) indicate non-significant effect of interaction also on time taken to 50 percent silking. However, significant effect of N levels was noted on this trait. Crop fertilized @ 250 kg N significantly delayed silking (52.24 days) over 150 kg N (49.59 days). However, 250 and 200 kg N levels were statistically at par with each other. Akbar et al. (2) and Rasheed et al. (23) also concluded that abundant consumption of nutrients increased the number of days to silking. Time taken to 50 percent silking was influenced by weed-crop competition durations. Weed free plots (P₆) caused maximum delay in time taken to 50 percent silking (52.67 days) and it was statistically at par with P₁ (52.27 days) and P₂ (51.1.4 days) where weeds were allowed to compete with maize crop for 2 and 3 weeks, respectively. The earliest silking was observed in weedy plots (P₅) (49.09 days). The stress caused by increased weed-crop competition durations may be reason of early silking (1).

Number of rows per cob

Non-significant effect of interaction of nitrogen levels and weed-crop competition durations was observed on number of rows per cob (Table 1). However, application of nitrogen significantly influenced number of rows per
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250 kg N produced significantly more number of rows per cob (15.46) than 150 kg N (13.37) but it was statistically similar to 200 kg N (14.40). These results agree to those of Ahmad and Saeed (1). Average of two years data also exhibited a significant effect of weed-crop competition durations on number of rows per cob (Table 1). Weed free plots (P6) produced maximum number of rows per cob (15.53) and was statistically at par with P1 (15.18) and P2 (14.64). Minimum number of rows per cob (13.18) was obtained from P5. Ansar et al. (8) also reported similar findings.

Number of cobs per plant

Two years pooled data (Table 1) revealed that differences among means for number of cobs per plant due to interaction of N levels and weed-crop competition durations were statistically non-significant. However, individual effects of nitrogen levels and weed-crop competition durations were significant. The data showed significant increase in number of cobs per plant in 250 kg N (1.24) over 150 kg N (1.11). However, 250 and 200 kg N levels were statistically similar. These results are in line with those of Nandal and Agarwal (18) and Short et al. (26). Weed free plots (P6) produced maximum number of cobs per plant (1.34) over all other weed-crop competition durations. The lowest number of cobs per plant (1.05) was recorded in P5. Similar results were also reported by Nawab et al. (19).

Grain yield

A perusal of data (Table 2) revealed significant effect of interaction of nitrogen levels and weed-crop competition durations. Maximum grain yield was obtained from N3 x P6 (7.79 t/ha) followed by N2 x P6 (7.54 t/ha), N3 x P1 (7.53 t/ha) and N3 x P2 (7.26 t/ha). These results are in line with those of earlier workers (15, 17, 30) who reported increase in yield of maize with N application at higher rates. Weed-crop competition upto harvest at each nitrogen level significantly reduced grain yield but these losses due to different weed-crop competition durations were more severe under low fertility.
level (N₁). Minimum grain yield (2.60 t) was produced by N₁ under weedy check plots (Π₅). Similar results have also been reported earlier (14, 16, 20, 22, 27).

Total fresh weight of weeds

The data (Table 3 and 4) showed that individual as well as interactive effects of nitrogen levels and weed-crop competition durations on total fresh weight of weeds were significant. Each increase in nitrogen level steadily increased the total fresh weight of weeds. Maximum fresh weight of weeds (522.6 g/m²) was recorded where nitrogen was applied @ 250 kg (N₃) and it was 35

Table 3. Effect of nitrogen levels and weed-crop competition durations on fresh weight of weeds.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Fresh weight of weeds (g/ m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Nitrogen Levels</td>
<td></td>
</tr>
<tr>
<td>N₁ (150 kg/ ha)</td>
<td>387.2 c</td>
</tr>
<tr>
<td>N₂ (200 kg/ ha)</td>
<td>471.6 b</td>
</tr>
<tr>
<td>N₃ (250 kg/ ha)</td>
<td>522.6 a</td>
</tr>
<tr>
<td>LSD 5%</td>
<td>11.96</td>
</tr>
<tr>
<td>(b) Weed-crop competition durations</td>
<td></td>
</tr>
<tr>
<td>P₁ = 2 WAS</td>
<td>114.31 e</td>
</tr>
<tr>
<td>P₂ = 3 WAS</td>
<td>540.80 c</td>
</tr>
<tr>
<td>P₃ = 4 WAS</td>
<td>796.30 b</td>
</tr>
<tr>
<td>P₄ = 5 WAS</td>
<td>1015.00 a</td>
</tr>
<tr>
<td>P₅ = 15 WAS (Full season weed competition)</td>
<td>296.70 d</td>
</tr>
<tr>
<td>P₆ = OWAS Weed free control</td>
<td>0.00 f</td>
</tr>
<tr>
<td>LSD 5%</td>
<td>14.45</td>
</tr>
<tr>
<td>Interaction</td>
<td>25.03</td>
</tr>
</tbody>
</table>

Any two means not sharing a common letter differ statistically at 5% probability level. WAS = Weeks after sowing, NS = Non-significant, LSD = Least significance difference.

Table 4. Effect of interaction between nitrogen levels and weed-crop competition durations on fresh weight of weeds (g/ m²).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>P₁ (2 WAS)</th>
<th>P₂ (3 WAS)</th>
<th>P₃ (4 WAS)</th>
<th>P₄ (5 WAS)</th>
<th>P₅ (15 WAS-full season competition)</th>
<th>P₆ (0 WAS-weed free control)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N₁ (150 kg/ ha)</td>
<td>86.72 m</td>
<td>464.1 h</td>
<td>464.1 h</td>
<td>877.8 c</td>
<td>219.3 k</td>
<td>0.00 m</td>
</tr>
<tr>
<td>N₂ (200 kg/ ha)</td>
<td>120.31 l</td>
<td>546.9 g</td>
<td>546.9 g</td>
<td>1046.0 b</td>
<td>303.9 j</td>
<td>0.00 m</td>
</tr>
<tr>
<td>N₃ (250 kg/ ha)</td>
<td>135.9 l</td>
<td>611.5 f</td>
<td>611.5 f</td>
<td>1120.0 a</td>
<td>366.90 i</td>
<td>0.00 m</td>
</tr>
</tbody>
</table>

Any two means not sharing a common letter differ statistically at 5% probability level. LSD N x P=25.03.
percent higher than minimum value obtained from N @ 150 kg (N₁) (387.2 g/m²). Availability of balanced nutrients at higher nitrogen levels resulted in better growth. These results confirm the findings of Akhtar et al. (4) who reported increase in weed biomass with increased nitrogen application.

There was a gradual increase in total fresh weight of weeds with the increase of weed-crop competition duration upto 5 WAS (P₄) while fresh weight was reduced where weed-crop competition remained throughout crop growth period (P₅).

In case of interaction, higher fresh weight of weeds (1120 g/m²) was recorded in N₂ x P₄ (N @ 250 kg/ ha with weed-crop competition duration upto 5 WAS) while N₁ + P₁ produced the lowest (86.72 g/m²).

**CONCLUSION**

The study concludes that application of nitrogen @ 250 kg under weed free conditions significantly increased maize yield and its components. Under low nitrogen level, additional stress brought by weeds further increased the suppression of maize growth and development which require more intensive weed management. The variation in weather data of two years had no significant effect on yield and yield components.

**REFERENCES**
