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PHENOLOGY, GROWTH AND YIELD CHARACTERISTICS OF MAIZE AS AFFECTED BY ROW SPACING AND NITROGEN PLACEMENT METHODS

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Abstract

An experiment entitled "Phenology, growth and yield characteristics of maize as affected by row spacing and nitrogen placement methods" was conducted at Research Farm of Agronomy, The University of Agriculture Peshawar, during kharif 2015. Randomized complete block design with split plot arrangements (RCBD split plot) having four replications were used. Row spacing (45, 55, 65 and 75 cm) were allotted to main plots while nitrogen placement methods (control, single side of the row, between the rows and both sides of the row,) were assigned to sub plots. Maximum days to 50% flowering (54.8) and days to 50% tasseling (62.5) were recorded for 45 cm row spacing while higher ear weight at maturity (76.4 g) and more number of grains ear^{-1} (376.4) were recorded for 75 cm row spacing and grain yield (2226.2 kg ha^{-1}) was obtained from row spacing of 65 cm row spacing. Similarly, more number of days to 50 % silking (63.6), higher ear weight at maturity (77.4 g), more number of grains row^{-1}(339.4) and higher grain yield (2184.9 kg ha^{-1}) was recorded from nitrogen placement to both sides of the row. All the interactions (RS×NP) were found non-significant for all the parameters. It is concluded that maize preferably sown at 65 cm row spacing with nitrogen applied to both sides of the rows method to get maximum yield.

Key words: *Row spacing, Nitrogen placement, tasseling, silking and grain yield.*

INTRODUCTION

Maize *(Zea mays* L.*)* is an important food and feed crop of the world and is often referred as "the king of grain crops". It ranks third in world production after wheat and rice and is important cereal crop of Pakistan. It is grown extensively with equal success in temperate, subtropical and tropical regions of the world. Besides being an important food grain for human consumption, maize has also become a major component of livestock and poultry feed (Witt and Pasuquin, 2007). It is estimated that its 70% production is used directly or indirectly as food and rest of it find its ways to starch manufacturing and poultry industries. In spite of high yield potential of maize, its yield per unit area is very low as compared to advanced countries of the world. The area of maize cultivation is 1142 thousand hectares with a total annual production of 4936 thousand tones in Pakistan (MNFSR, 2015). The average grain yield of maize (4321 kg ha^{-1}) is very low as compared to the production potential of the cultivars. Maize responds variously to different environments under different agro management practices and this yield can be enhanced by providing best management practices and improved inputs (Javed *et al.*, 2006).

Planting pattern exerts great influence on crop yield. Row spacing is a critical factor for increasing crop yield. In very narrow row spacing most plants remain barren, small ear size and plants are prone to lodging, diseases, pest and resulted in decreased grain yield whereas, wider row spacing may be suitable alternative and may result in higher yield as compared to narrow row spacing Johnson *et al.* (1998). The unavailability of modern production technology and high prices of inputs are major hurdles for attaining high yield of maize in Pakistan (Farhad *et al.*, 2009).

Generally, the most appropriate spacing is one, which enables the plants to make the best use of the conditions at their disposal (Lawson and Topham, 1985; Malik *et al*., 1993). Too close spacing interferes with normal plants development and increase competition resulting in yield reduction, while too wide spacing may result in excessive vegetative growth of plant and abundant weed population due to more feeding area available. Therefore, use of optimum plant population per unit area without exceeding the economic threshold can increase the competitive ability of the crop plants in weed-infested field (Murphy *et al.*, 1996). Row spacing in maize has great effect on grain yield. Weed growth is most likely reduced because of increased light interception by the crop canopy in narrow rows early in the growing season. While reducing weed growth, yields may be increased in sugar beet or not affected in maize and dry bean (Alford *et al*., 2004) but research in northern areas of the United States has shown yield increases of up to 9.9% by growing maize in rows narrower than 76 cm (Paszkiewicz, 1998; and Roth, 1997).

Nitrogen (N) fertilization is a key component to high corn grain yield and optimum economic return. It is essential for enzymatic biochemical and physiological reactions in plant metabolism (Balasubramaniyan and Palaniappan, 2001). Nitrogen availability in soil for optimum plant growth and development is very low in Pakistan because of high temperature and very low organic matter (Tisdale *et al*., 1997). Nitrate-nitrogen leach out from field soil decrease soil fertility and causes water pollution which can be minimized through best management practices (Russelle *et al., 1981*), applying nitrogen in split doses, and proper nitrogen placement method (Martin *et al., 1994* and Ritter et *al., 1993*). Nitrogen applied with side placement is efficiently utilized and promote bio chemical processes and utilize soil moisture more easily than other methods (Lehrsch *et al.,* 2001). Maize behaves to take up N rapidly with maximum rate throughout the vegetative period near silk, therefore, side dressing of nitrogen will be the best way to fulfill this high nitrogen requirement (Hanway, 1962). Efficient utilization of nitrogen requires proper method of application and time during life span of crop (Pearson, 1994). To investigate the response of maize in growth and development under different row spacing and nitrogen placement this experiment was designed.

MATERIALS AND METHODS

An experiment entitled "Phenology, growth and yield characteristics of maize as affected by row spacing and nitrogen placement methods" was conducted at Research farm of agronomy, The University of Agriculture Peshawar during kharif 2015. The experiment was laid out in randomized complete block design with split plot arrangements (RCBD split plot) having four replications. Pahari variety was planted and a plot size of 2m x 5.25 m was used. The experiment was consisted of two factors, row spacing was assigned to main plots and N application method to sub plots. Each plot was consisted of 7 rows. There were four row spacing (45, 55, 65 and 75 cm) and four nitrogen placement methods (single side banded, double side banded, between the rows and controlled. Phosphorus as a basal dose was applied at the rate of 60 kg ha^{-1} from SSP. N at the rate of 120 kg ha^{-1} was applied from urea , half 30 days after emergence and remaining half at knee stage. All the phosphorus fertilizer was applied at the time of sowing. Recommended irrigation schedule was followed. Weeds were controlled manually by hoeing. All agronomic practices were carried out uniformly for all the experimental units throughout the growing season. Maize was harvested at physiological maturity, as indicated by the appearance of a black abscission layer at the base of grains (about 30-35% grain moisture content). After harvest, crop plants were sundried and then tied in small bundles. Afterwards, ears were separated from the stalk and further sundried for a few days before shelling, which was done at 14% seed moisture content.

Statistical analysis: The data was analyzed statistically by using analysis of variance techniques appropriate for randomized complete block design with split plot arrangement. Means was be compared using LSD test at 0.05 level of probability, when the F-values significant (Jan *et al.*, 2009).

RESULTS AND DISCUSSION

Days to 50 (%) tasseling: Data regarding days to 50% tasseling is shown in table no 1. Statistical analysis showed that days to tasseling were significantly ($p<0.05$) affected by row spacing while nitrogen application methods and their interaction (RS X NP) were found non-significant. Maximum numbers of days to 50% tasseling were 54.8 days obtained from row spacing 45 cm while minimum number of days 49.4 were observed from row spacing 75 cm. Thus, plants cultivated with wider rows reached 50 (%) tasseling slightly earlier than plants Cultivated in narrow rows. This might be due to the fact that 75 cm row spacing have created better soil environment for proper root development and efficient supply of nutrients. Modarres *et al*. (1998) observed that decreased row spacing took more days to tasseling. Thus, plants cultivated with wider rows reached 50 (%) tasseling slightly earlier than plants Cultivated in narrow rows. Later tasseling might be attributed to intense competition among the plants for resources, such as light interception. Basically, as the distance between plants decrease the number of plants in a planting pattern increases and competition among individual plants increases (Duncan, 1984).

Days to 50 (%) silking: Data regarding days to 50% silking is shown in table no 1. Statistical analysis showed that days to silking were significantly ($p<0.05$) affected by row spacing and nitrogen placement methods while their interaction (RS X NP) were found non-significant. Maximum number of days to 50% silking were (63.6) days obtained from double banded nitrogen placement while minimum number of days (58.1) were observed from controlled. Delayed tasseling in nitrogen efficient plots may be attributed to vigorous vegetative growth and increased light use efficiency with increase in use of nitrogen (Frederick and Comberato, 1995). Similar results are reported by Dolan *et al*. (2006) and Li (2003) who investigated that higher nutrients availability and favorable soil conditions may cause vigorous crop growth and delay phenology. Similarly maximum number of days to 50% silking were (62.5) days obtained from 45 cm row spacing while minimum number of days (57.3) were observed from 75 cm row spacing. This might be due to the fact that wide row spacing provided suitable environment for proper root development and resulted early silking (Edmeades *et al*., 1993). This could be attributed to the high density of plant population which adversely affected availability of sunlight and nutrients to the plants. These results are in agreement with the findings of Shah *et al.* (2001). Modares *et al.* (1998) suggested two reasons that caused a delay of silking in higher plant densities. The first reason was due to hierarchical pattern in reproductive development in which tassel growth dominates ear growth (apical dominance) and the second was an assimilate shortage in which case insufficient translocation of assimilates to the ear at high plant densities occurs.

Ear weight at maturity (g): Data regarding ear weight at maturity is shown in table no 1. Statistical analysis showed that ear weight was significantly ($p<0.05$) affected by row spacing and nitrogen placement methods while their interaction (RS X NP) were found non-significant. Maximum ear weight was (76.4 g) obtained from 75 cm row spacing while minimum (64.2 g) was observed from 45 cm row spacing. This might be due to the proper aeration of roots which enhanced its nutrient absorption capacity. These results are in conformity with those of Shah *et al.* (2001) who reported that maximum ear weight weight was recorded at 75 cm row spacing. The reason for highest ear weight in 75 cm row spacing could be due to high light interception and low competition for moisture resulted in high photosynthate accumulation. Plants with les available space faced with tough competition for solar radiation, moisture and nutrients. Similarly maximum ear weight (77.4 g) was obtained from double banded nitrogen placement while minimum (63.3 g) was observed from controlled. The ear weight was maximum at double banded nitrogen it might be due to more nitrogen is necessary for ear development so our results concur partly with observations made by Sanjeev and Bangarwa (1997) and Torbert *et al.* (2001) who reported that the ear weight increased with increasing nitrogen levels. Increase in ear weight at higher nitrogen levels might be due to the lower competition for nutrient that allowing the plants to accumulate more biomass with higher capacity to convert more photosynthesis into sink resulting ear weight. These results are also in agreement with Zeidan, *et al.* (2006) who concluded that ear weight was maximum at the highest of nitrogen levels.

Table 1. Days to 50 (%) Tasseling, Days to 50 (%) Silking and Ear weight (g) as affected by row spacing and nitrogen placement methods.

Row Spacing (RS)	Days to 50 (%) tasseling	Days to 50 (%) Silking	Ear weight at maturity (g)
45 cm	54.8 a	62.5 a	64.2 b
55 cm	52.9 b	60.4 a	67.3 b
65 cm	51.2 ab	58.9 ab	73.3 a
75 cm	49.4 b	57.3 b	76.4 a
LSD (0.5)	1.87	1.99	3.95
Nitrogen placement (NP)			
Control	52.4	58.1 b	63.3 b
Single side the row	53.2	59.7 ab	68.4 b

Continued table 1

Both sides of the row	53.9	63.6 a	77.4 a

Between the rows	52.8	60.8 a	72.8 b
LSD (0.05)	NS	1.83	5.12
Interaction			
RS x NP	NS	NS	NS

NS = Non-significant

Number of Grains ear^{-1}: Data regarding number of grains ear^{-1} is shown in table 8. Statistical analysis showed that number of grains ear^{-1} were significantly ($p<0.05$) affected by row spacing and nitrogen application methods while their interaction (RS X NP) were found non-significant. Optimum number of grains ear^{-1} (358.4) was obtained from 75 cm row spacing, while the minimum number of grains ear^{-1} (288.8) was observed from 45 cm row spacing, the possible reason for that could be suitable space available to the crop plants for better interception of sunlight to increase the photosynthetic activities and better chance of fertilization during the tasseling silking period of the crop. The minimum number of grains ear^{-1} was obtained from 45 cm row spacing, it might be due to the suppressive influence of dense population of maize on the number of grains ear^{-1} Ahmad *et al.* (2010). Likewise, Bavec & Bavec, (2002) reported that number of grain row^{-1} and number of rows ear^{-1} significantly changed due to increase in plant density. In similar fashion, many researchers observed that grains ear^{-1} usually decrease with increase in plant population. For instance, Remission & Lucas, (1982) and Bavec and Bavec, (2002) noted that increase in planting density decreased number of grains ear^{-1}. Similarly optimum number of grains ear^{-1} (339.4) was obtained from nitrogen placement both side of the rows while minimum number of grains ear^{-1} (274.6) was obtained from control plots. Application of nitrogen to both sides of rows near to plant roots make it readily available to the crop plants and also its better utilization over other. These results are in agreement with the findings of Shafi *et al.* (2011) and Shah *et al.* (2001) who reported significant variation in number of grains ear^{-1} under different nitrogen placement methods. Ahmad *et al.* (2002) also concluded that significantly more grains ear^{-1} were recorded in maize with N fertilizer be applied as band placement against the minimum in broadcast method.

Missed grains row^{-1}: Data regarding missed grains row^{-1} is shown in table no 2. Statistical analysis showed that missed grains per row were significantly affected by nitrogen placement methods, while row spacing and their interaction (RS X NP) was found non-significant. Maximum number of missed grains row^{-1} (0.7) was obtained from controlled while minimum number of missed grains (0.5) was obtained from double side banded. .the possible reason for these results could be that nitrogen is important for development of ear and grains. These results are in accordance with Abuzar *et al*, (2011) and Andrade *et al*, (1993) who observed that an increase in plant density decreases the number of grains per cob. Similar results have been reported by EL-Sheik, (1998) who reported that the number of grains per ear row of corn had significantly affected by nitrogen rates. Ahmad *et al*, (2002) also concluded that significantly more grains ear^{-1} was recorded in maize with N fertilizer applied as band placement.

Grain yield (kg ha^{-1}): Analysis of the data showed that grain yield was significantly affected by nitrogen placement methods and row spacing while their interaction (RS X NP) was found non-significant. Maximum grain yield was (2226.2 kg ha^{-1}) obtained from 65 cm row spacing while lower (1805.0 kg ha^{-1}) was observed from 75 cm row spacing. This might be due to the fact that 65 cm row spacing have created better soil environment for proper root development and efficient supply of nutrients. Our results are in conformity with those of Modarres *et al*. (1998) who observed more grain yield at 65 cm row spacing due to less competition among the plants for resources, such as light interception, water and nutrients. This might be due to the fact that wide row spacing provided suitable environment for proper root development and plant growth. The results are in agreement with Abuzar *et al*. (2011) who observed the minimum grain yield at the highest population Similarly maximum grain yield (2184.9 kg ha^{-1}) was obtained from double banded nitrogen placement while minimum (1754.0 kg ha^{-1}) was observed from control. The increase in grain yield of maize by band placement was probably due to more N uptake and its continuous supply to maize plants near plant roots throughout the growing period and improved all physiological characteristics of the plant that led to better yield attributes and grain yield Kaiser *et al*. (2005). These results are in agreement with the findings of Ahmad *et al*. (2002) who found more grain yield of maize with band placement of nitrogen.

Table 2. Number of grains ear^{-1}, Missed grains row^{-1}and Grain yield (kg ha^{-1}) as affected by row spacing and nitrogen placement methods.

Row Spacing (RS)	Number of grains ear^{-1}	Missed grains row^{-1}	Grain yield (kg ha^{-1})

45 cm	288.8 d	0.5	1870.5 b
55 cm	306.2 c	0.5	1919.5 b
65 cm	337.8 b	0.4	2226.2 a
75 cm	358.4 a	0.4	1805.0 b
LSD (0.5)	22.3	NS	255.73
Nitrogen placement (NP)			
Control	274.6 d	0.7 a	1754.0 c
Single side the row	296.8 c	0.6 b	1909.6 bc
Both sides of the row	339.4 a	0.5 c	2184.9 a
Between the rows	326.3 b	0.6 b	1972.6 ab
LSD (0.05)	17.6	0.08	216.3
Interaction			
RS x NP	NS	NS	NS

NS = Non-significant

CONCLUSION

On the basis of the above results it was concluded that maize sown at 65 cm row spacing gave higher yield (2226.2 kg ha^{-1}) which is significantly better than other row spacing. Nitrogen placement of both sides of the rows gave maximum ear weight and higher yield of (2184.9 kg ha^{-1}) therefore row spacing of 65 cm along with nitrogen placement to both sides of the row is recommended for sustainable yield.

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